ILLUMINATING ENGINEERING

OCTOBER 1950

Part II—Contemporary Lighting in Homes

Two Decades of Carbon Arc Research

Acrylic Plastic for Light Control

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New Glass Developments

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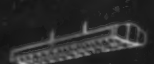
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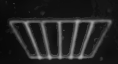
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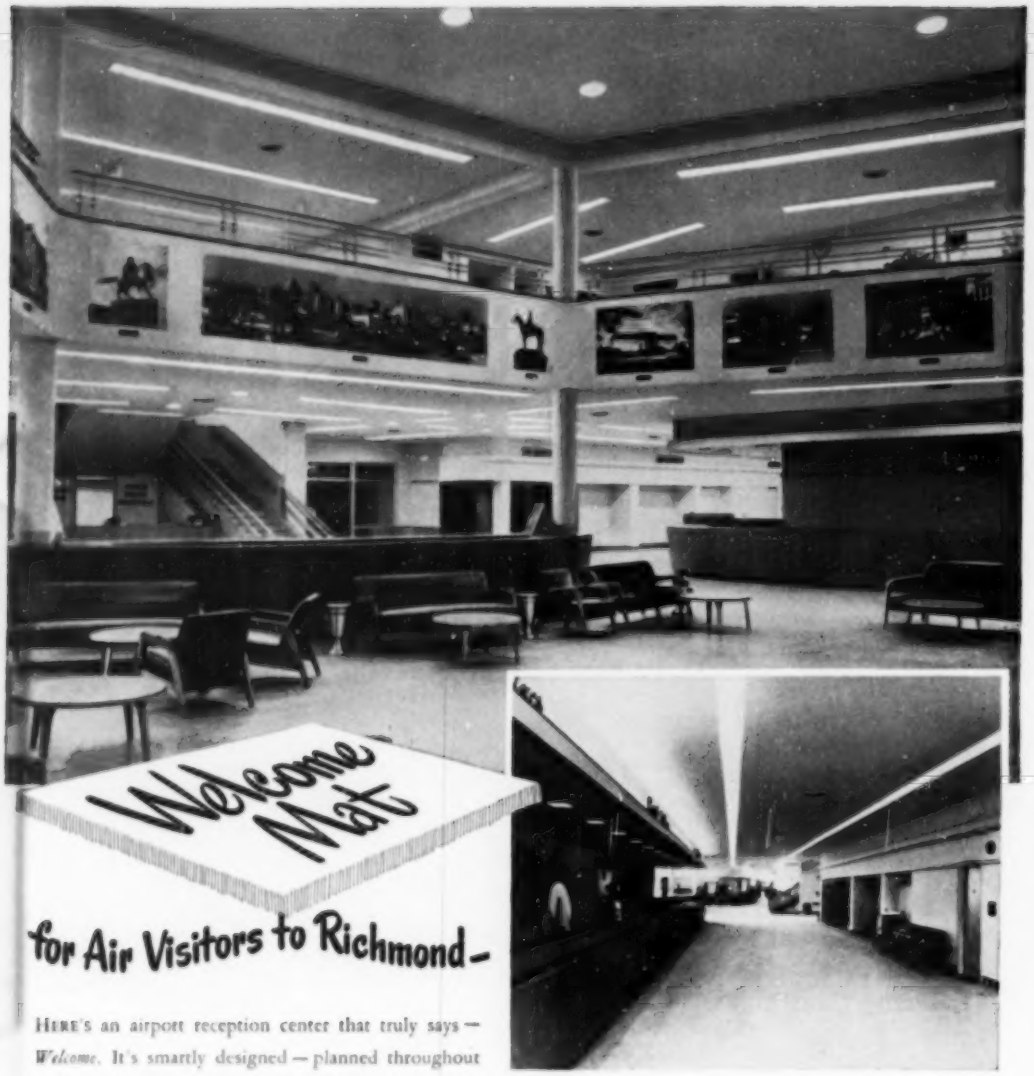

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THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

OCTOBER 1950

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No. 10

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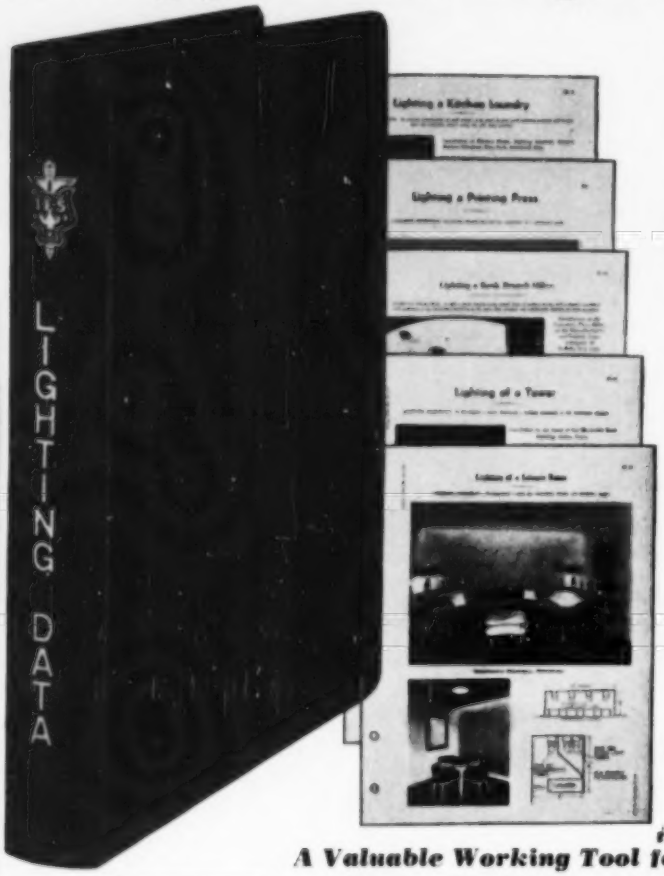

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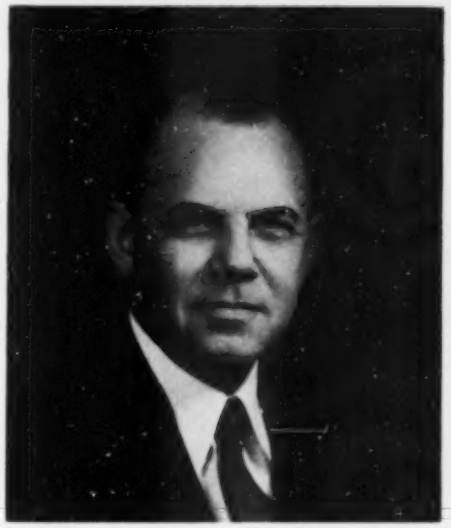


Walter Sturrock, President, 1950-1951

Illuminating Engineering Society

WALTER Sturrock, 46th President of the Illuminating Engineering Society, is well known in his profession for his contributions in several fields of specialization, and for his long devotion to the broad objectives of the Society. As an authority in the field of office lighting, to name one of his special interests, he is still identified with the work of the Building Owners and Managers Association in the advancement of lighting standards for this important sector of business. His long service on the committees and as an officer of the Society, together with his contacts with schools and colleges, had established his reputation as a leader in lighting education. In 1946, in his 30th year of his career, he was among the first to be elected to the Society's new rank of Fellow. All of the foregoing, which is part of the formal record, attests the thorough preparation of the new President for his new responsibilities.

Mr. Sturrock's fitness for leadership begins with his boyhood training with a large closely-knit family, where he learned early the importance of team work and loyalty; the power of faith founded on strong convictions. When the family moved to Ithaca, N. Y. so that the children might have the chance for a college education, it was a mutual adventure. They all pitched in with their capacity for hard work, and as a result five of the family, Walter included, won degrees from Cornell University.

Things happened fast thereafter. First came his connection with the General Electric Company, Nela Park. As a new man with the company's Lamp Department, Mr. Sturrock had scarcely become acclimated when World War I came along. He enlisted as a private, 1st class, in the old Signal Corps. Presently he was assigned to Aviation School at M.I.T., and soon thereafter was a 2nd lieutenant, heading for France.

On his return to his profession at the end of the war, Mr. Sturrock began the work which was to lead ultimately to the honor he has now won as the head of I.E.S. Lighting as a science, at the start of this period, was just learning how to apply measure to its problems. Much unscientific practice and hearsay dogma prevailed. This had to be countered with education and training on a rush order basis, for the whole electrical business was in the midst of a surge of expansion. This was the opportunity Walter Sturrock responded to with such success. In this pursuit he had the advantage of working with many of the pioneer great of the new profession. He worked closely with many of the men who were his predecessors in the Presidency of the Society.

When World War II came along, Walter Sturrock had 25 years of rich professional experience to make available to the government department heads who had to get the largest results with material in short supply. For one who knew the power of lighting as related to the seeing process many of the problems of the war effort had their solution in illumination techniques.

The 46th President of the Society has not had to develop his distinguished career unaided. He is, in fact, a solid family man whose wife and daughters keep him fit and inspired to carry on his work for better living through better lighting. He has kept active in civic projects of East Cleveland; he has been President of the local P.T.A., and President of the Board of Trustees of Windemere Methodist Church. He gives generously from his experience as his time permits, and proved capacity for leadership makes his counsel much sought. In deed, as well as in word, he adheres to the principle that light and good works go together.

Two Techniques in School Libraries

SWIFT HALL, University of Chicago's famous library, is of traditional architectural design. Lamont Library at Harvard University is modern. Both, however, have successfully supplied high level fluorescent lighting.

In Swift Hall, shown above, the ceiling is typical Gothic with arches on 12-foot centers and beams between the arches on relatively close centers. It varies in height from 13 feet at the sides to 28 feet at the apex. Bookcases follow the contour of three walls of the room, between the windows.

The original general lighting, installed in 1926, was provided by two chandeliers, each with twenty-four 150-watt lamps. Four of the 12 tables in the room were equipped with indirect incandescent table lamps, increasing the illumination level on the working area to 10 footcandles average. General illumination from the two chandeliers was approximately 4.2 footcandles. The room was a dreary place to work—usually only a third of the tables were used.

Preservation of the traditional appearance was a factor in relighting the room; the Gothic ceiling somewhat of a problem. The scheme shown was finally evolved—three rows of suspended fluorescent luminaires running the entire length of the room. The final design employs direct-indirect, shielded and baffled two-light 85-watt units. The outside rows are mounted 11 feet 2 inches above the floor, with the center unit mounted at 12 feet 5 inches height.

Initial average illumination level was 45 footcandles, with a distribution uniformity of approximately 88 per cent and a brightness ratio not exceeding 3:1. The maintained level is 28 footcandles. Adequate switching was provided in order to afford the flexibility necessary to supplement varying amounts of daylight.

Concurrently with the relighting, a decorating program was also undertaken. The colors selected for the reading room were light chrome yellow for the ceiling; turquoise green on the south wall; light gray for the east and west walls, and a wine red on the north walls. The effect was startling. The occupancy of the room increased from 33 per cent to about 98 per cent of capacity.

Direct contrast in architectural design is apparent in Harvard's Lamont Library. The same excellent lighting results prevail, however. The lobby

Lighting data and photograph of Swift Hall were supplied by W. B. Zellner, Assistant Superintendent, University of Chicago. Data and pictures of Lamont Library, Harvard University, from Mr. H. L. Harrison, The Miller Co., Meriden, Conn.

Lamont Library, gift of Thomas W. Lamont, Harvard University, has attracted wide favorable interest in architectural circles. Considerable study was given to the lighting. Easy reading of books, easy writing of notes and extracts from books, with low brightness and absence of glare, was the objective.

and main reading rooms are illuminated with single-lamp aluminum Troffers on three-foot centers, operating at 120 milliamperes, with 4500K fluorescent lamps. Maintained illumination level is 25 to 30 footcandles, with a brightness factor of one-half candle per square inch at the source. The cut-off shielding of the light source is 45° laterally and 47.5° end in, due to the baffles being on six-inch centers. Cove lighting has been employed around the perimeter of the room.

In the alcoves where book selections are made, louvered luminaires have been employed, using two eight-foot or two six-foot 120 and 200 milliampere 4500K slimline lamps, providing excellent distribution of light for quick selection of titles. The mezzanine floors use 200 milliampere louvered luminaires adjacent to the bookstacks, providing 30 to 35 footcandles for reading and taking notes.

Furniture and walls throughout are light in color, to keep brightness contrast low. Floors are of cork, in medium brown.

Television Studio Illumination

H. M. GURIN
By R. L. ZAHOUR

THE EVOLUTION of television has been so rapid that present equipment and results can scarcely be identified with the original apparatus. Advances in new studio equipment transmission and reception have created entirely new requirements for present-day operation on a sound technical and economic basis. One of the most significant elements which has contributed to this advance has been the development of highly sensitive camera pickup tubes. Since studio illumination plays such an important part in realizing the advantages to be gained from the proper use of these new pickup tubes, it is appropriate that the methods and techniques employed be carefully scrutinized.

In the early days of television experimentation around 1936, lighting equipment was similar to that used in the motion picture industry, Fig. 1. Very shortly thereafter it became apparent that the actual use of this equipment had to be radically altered from the motion picture practice because of the mobility of the number of cameras required for simultaneous use. In addition, because of the relative insensitivity of (the iconoscope) the camera pickup tube, which was then employed, a tremendous amount of light, in the order of 1000 to 2000 footcandles incident, was required. As a result, large cumbersome units, radiating an uncomfortable amount of heat, were displaced by clusters of reflector lamps mounted in special fixtures as shown in Fig. 2. This system led to a much greater flexibility in manipulating the light sources and clearing the floor for greater camera freedom but did not solve the problems of heat. A further difficulty existed in the ability to obtain a satisfactory degree of modeling light because of the high foundation light necessary to obtain any picture at all.

During the past year, the introduction of the much more sensitive image orthicon was a major step forward in obtaining the excellent results some of the more fortunate people in the larger cities have almost learned to take for granted.

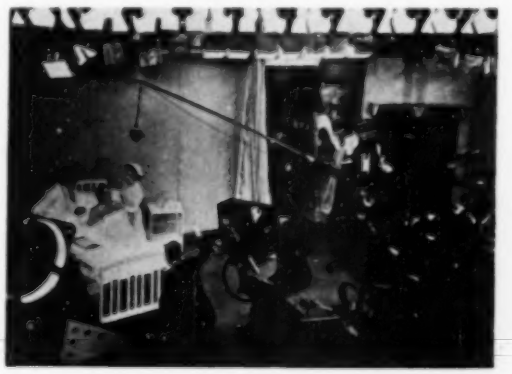
It must be borne in mind that the overall picture is affected not only by the studio lighting but by a great many other factors which are probably not so obvious. The alignment of the camera pickup tube itself with respect to its tonal gradations of the gray scale (or shading), the studio equipment, the operation of the transmitter, external interference from diathermy machines, aircraft, ignition systems, etc. and, last but not least in importance, the actual alignment and adjustment of the receiver, all affect the end result. Unfortunately, criticism of the picture quality too often has been directed to the lighting without due consideration of the other factors mentioned.

Problem

The ability to obtain suitable lighting in a television studio is complicated by the need for uninterrupted action which can be instantaneously transferred from one field of view to another. There is no time to halt, reset camera positions, adjust lens for different depths of fields, readjust lights, shift the microphone, etc. as is possible on a motion picture set. The instantaneous switching from one scene to another without mutual interference of lights adds to the complexity of the operation.

A problem, however, common to both motion pictures and television studio practice is the need of selecting the proper quality of light for a given camera pickup characteristic to obtain a satisfac-

Figure 1. Early TV lighting technique was borrowed from movie studio practice. Floor areas cluttered with cables and lighting equipment, left little space for TV camera movements.



Authors, National Broadcasting Co., New York, and Westinghouse Electric Corp., Bloomfield, N. J., respectively.

tory rendition of colors in a suitable gray scale for black and white pictures. The solution of this difficulty will permit the use of color in scenery and costuming with its associated favorable psychological effect on the performers.

Another problem, faced on television, has been the limited space, usually converted broadcast studios, in which operations were carried out. As a result, the physical factors of size, weight of equipment, ease in manipulation and general handling are important considerations. In addition, the problem of heat dissipation for the required illumination cannot be ignored.

Methods of Attack

The need for suitable lighting has long been recognized and even with the advent of the image orthicon pickup tube the problems of correct illumination properly applied have not been completely solved but definite strides to an acceptable solution have been made. It has been found that a light source should provide a spectral characteristic correctly balanced to that of the camera pickup tube used and psychologically suited to the participants or actors within the television studio. Spectral characteristics of several different image orthicon tubes are illustrated in Fig. 3. Figures 4 and 5 show the spectral characteristics of a number of available fluorescent lamps as well as that of sunlight, the average eye response and of the conventional filament or incandescent light.

When the various light sources are combined with a No. 5820 image orthicon, the pickup tube now being rapidly accepted for studio use, an overall photographic response can be plotted by multiplying the relative sensitivity of the pickup tube with the relative energy of the source as shown in Fig. 6.

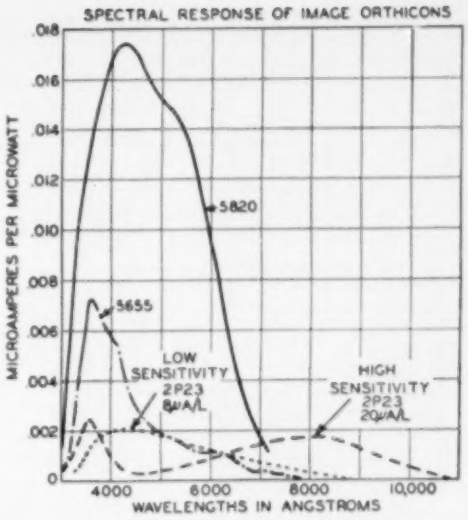


Figure 3. Spectral characteristics of several different Image Orthicon pick-up tubes.

It will be noted that when a filament light source is used, the combination leads to a curve which approaches the contour of the average eye response. This is significant since it leads to a tonal rendition in the gray scale which can be readily reconciled to the actual colors used in the scene. This objective can also be obtained with fluorescent light if a Wratten No. 6 filter is used at the camera. Because of these fortunate circumstances, fluorescent lights can be mixed with incandescent to excellent advantage.

No light source, however well matched to the pickup device, is efficiently utilized without a satisfactory reflector and housing.

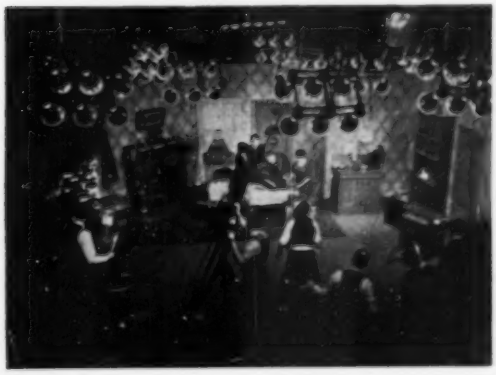
In television studio lighting such equipment may be classified into four types:

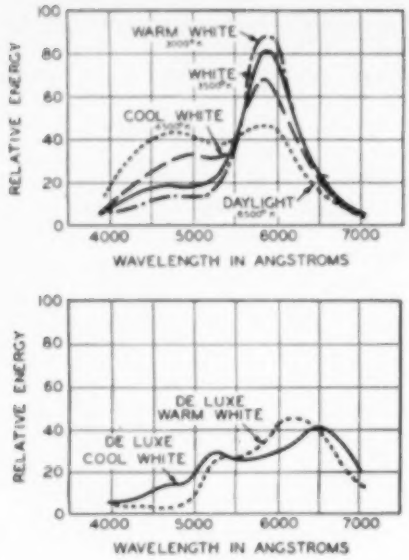
1. Floodlights
2. Spotlights
3. Strip Lights
4. Effects Lights

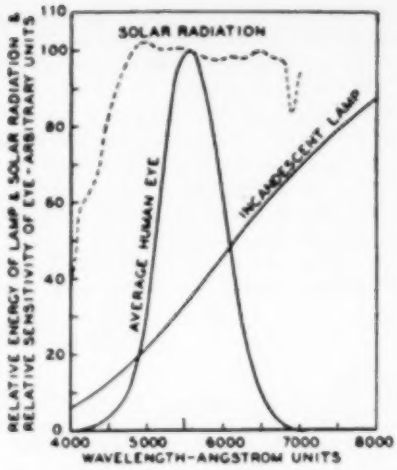
} with accessories

In general, floodlights are of the incandescent or fluorescent type. Incandescent floods are scientifically designed hyperbolic aluminum reflectors of matte Alzak finish weighing about five to seven pounds. Floods are made in sizes from 10 to 18 inches in diameter for use with lamps from 250 to 2000 watts. They are useful in providing a wide

Figure 2. To clear floor of lighting equipment and cables, clusters of reflector lamps mounted in special fixtures were suspended over TV studio area. This change, however, did not solve the heat problem



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INCANDESCENT LAMP
RELATIVE ENERGY OF LAMP & SOLAR RADIATION & RELATIVE SENSITIVITY OF EYE - ARBITRARY UNITS
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Figure 4. (Left) Energy distribution curves of fluorescent lamps. Figure 5. (Above) Spectral characteristics of solar radiation, incandescent lamps, and average eye response.

angle distribution of uniform illumination of moderate intensity.

Fluorescent floodlights consist of a rectangular aluminum housing 44 to 65 inches long 3½ to 5 inches deep, and 16 to 44 inches wide, equipped with 60° specular parabolic reflectors for either four or six lamps. The lamp circuits of a six-lamp fixture, for example, may be wired to permit one-third, two-thirds or full operation. Fluorescent fixtures weigh from 39 pounds with six 64-inch slimline lamps to 64 pounds with six 40-watt preheat fluorescent lamps. Ballasts are usually housed separately from the fixture and located as remotely as possible to reduce transmission of audible hum.

Spotlights usually assume the form of a cylindrical ventilated metal housing built in sizes for plano-convex or Fresnel lenses of 3 to 16 inches diameter, with projection lamps from 75 to 5000 watts respectively. These spots are generally provided with spherical Alzak specular reflectors and lampholders with an external adjustment handle which permits beam spread variations of 5 to 50 degrees. A frame on the front accommodates such accessories as barn doors or diffusers to mask the beam pattern or soften the light. Some spotlights have an inbuilt iris which permits a variation of sharply defined beam spreads of high intensity for creating artistic effects.

A strip light, as the name implies, is a metal trough-like fixture which houses a series of similar incandescent sources such as the PAR-38 or R-40 lamps, either spot or flood, or aluminum reflectors with 200- to 500-watt lamps. They are made in lengths from three to eight feet with six to fifteen outlets respectively usually wired to three circuits.

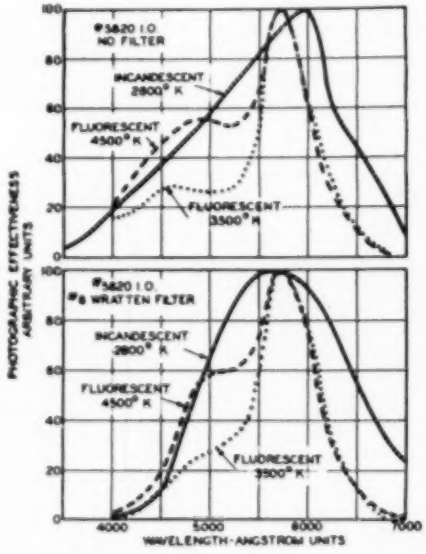

Figure 6. Photographic response curves of No. 5820 Image Orthicon for various white fluorescent lamps, and incandescent source.

Strip lights produce general shadowless illumination of low intensities, and serve in providing a uniform light on backgrounds, side walls and such, from overhead or side borders. Spread lens roundels and diffusers are available for modifying light beams of the individual lamps.

Effects lighting creations are often produced by a projector equipped with a motor-driven "effects disc" painted to create scenes such as moving storm clouds, moving fleecy clouds with rising or setting moon, moonlight water ripple, rising fire or smoke, falling leaves, ocean waves, and many other effects. Figure 7 shows a schematic view of an effects device.

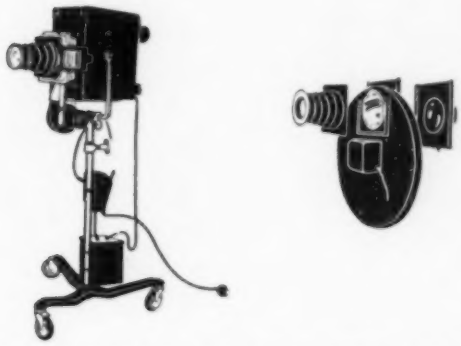

Figure 7. Mechanized projection equipment for producing effects.

Equipment Facilities

Good television studio practice favors the installation of a permanent grid which resembles an architectural system of rigid 1½-inch iron pipe cross members four to six feet apart, and hung as close to the ceiling as possible, with sufficient clearance for electric raceways, sheaves, conduits or ventilation ducts above. The grid may also be temporary. When temporary, the grid structure is supported by heavy vertical pipes rigidly anchored to the floor or walls, but can be readily removed.

In some television studio installations, catwalks above or around the grid are used for making adjustments, hanging scenery, etc. However, the sacrifice in the effective studio height due to catwalks may in some cases present a serious disadvantage.

It has been found good practice to suspend lighting equipment on pantograph devices spaced on four- to six-foot centers and fastened rigidly to the grid structure. The pantograph is constructed to prevent any side-sway, yet it permits raising or lowering of a lighting unit with its cable feeder from 18 feet to four feet above floor, while a universal clamp allows 360-degree horizontal rotation and 90-degree tilting of the fixture. (Fig. 12)

Earlier devices rotated and tilted the lighting fixtures by means of cables and pulleys. While this method appeared to be an operating convenience, no provisions were made for an appreciable lowering or raising of fixtures, which is a highly desirable feature in television studio lighting practice.

Electrical Control

An adequate electrical control system for television studio lighting consists of:

1. A system of power input.
2. A system of controls.
3. A circuit terminating patch or connecting panel for conveniently energizing branch circuits.
4. A system of branch circuits permanently and conveniently distributed over the studio area.

1. Power Input

Experience and present practices indicate that 20 to 40 watts per square foot of studio area is adequate for power requirements. Meters are usually provided on input lines so that the loads may be balanced and phased properly on a three-phase system.

2. System of Controls

A practical system of control in which power input is distributed, consists of a main master, submaster, and branch circuits which are easily manipulated through controls and switches that operate quietly. Since blackouts should be possible, a master switch is provided for all studio lights except "work lights," while a submaster switch controls all studio lights over a given work area. Fused branch circuits terminate at a switching panel which are connected by a patching or connecting system to outlets distributed throughout the studio. All panels and switchboards should be located at a convenient position within the studio so that the lighting man can view the scene. In the overall scheme, power is patched to the dimmers and the dimmed output is then connected through switch controls to the individual branch circuits appearing on wall patch panel. Dimmers are used only for effects such as fades, but not for control of amount of light.

Branch circuits are usually heavy enough to carry up to 2000 watts capacity. For special lighting effects, some grid circuits are wired to carry five kilowatts. A majority of the branch circuits terminate at the grid, while others feed wall out-

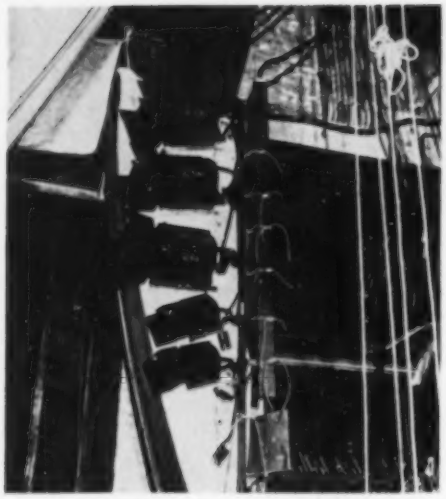

Figure 8. Spotlights with barn doors located in theatre stage wings, provide lower angle modeling light.

lets. It is considered good practice to provide one branch circuit for 20 to 30 square feet of floor area.

Applications

The application of these basic principles for power distribution and lighting controls can be adapted to various sizes of studios which can be classified into three categories.

The first, which requires the greatest degree of flexibility may be called the general purpose or workshop studio. Herein originate a wide variety of dramatic performances, commercial sequences, and almost any type of small musical or speech groupings. In a studio of this type the maximum mobility in scenery changes and camera movements are essential. As a result, the lighting system must also be capable of matching these requirements both in physical manipulation and in beam pattern and intensity control.

The second type of studio frequently used for television programming is the one in which an audience is present and which is used chiefly for theatrical presentations as in a variety show of the Texaco Star Theatre type. Here the television point of view is that of an observer in the theatre and varies primarily not so much from different angles as from the area of view between a close-up and a long-shot. The lighting problems are consequently not as complicated as in the workshop studio but results suffer sometimes from inadequate front fill light. Footlights are used only to a limited extent because of the unnatural effects. Follow spots have been found to be satisfactory for long-shots but usually fail to improve the appearance of the principal characters on close-ups because the sharp beam creates harsh shadows, and lines around the eyes, nose and mouth. Color gelatins, frequently used in theatres to create pleasing color tones, are almost completely lost to the television audience, and create an undesirable change in the gray scale.

Most of the lighting equipment is supported on battens and hoisted above the stage together with other scenic material, Fig. 8. Lower angle light for modeling is obtained by the use of standards located in the wings or on the sides of the theatre. Figs. 9 and 10 illustrate how the lighting effects are produced in the NBC Studios.

The third type of studio to which the facilities previously described can be applied on a small scale, is the one in which the set is essentially fixed in position and the program material is repetitive. The lighting can even be fixed if desired once the original plan has been established. Such a studio can be used for example for newscasting, interviews, quiz programs, kitchen demonstrations, etc. It is most desirable that the artistic effects obtained with spotlights for backlighting, accents, together with floods for fill and base lighting should be included since they add a great deal to the pictorial quality.

Having described the equipment and space in which the programs are to originate, the development of applications and techniques can be more readily studied.

Quantity of Light

For general illumination over a working area, intensities ranging from two to 150 footcandles may be used, depending upon the nature of the scene. This general illumination or incident light is measured with the color-corrected light sensitive surface of the meter facing the camera lens and perpendicular to the lens axis.

As a guide, the average footcandles of incident light required for the Type 5820 orthicon, range between 32 and 64, with a lens opening of f:8. Lens stops normally used to give sufficient depth of field lie between f:5.6 and f:8. Table I lists footcandles of incident light for various lens openings. The inherent characteristics of the pickup tube limit the highlight to shadow or contrast ratio for an average scene to approximately 30 to 1.

Figure 9. Scene from "Our Town." Sunshine effects through windows are created by overhead spotlights aimed from rear of background scenery, while other spotlights accent players.

Studio Lighting Technique

Studio lighting technique may be described in accordance with the following types:

1. Base or General Lighting
2. Accent Lighting
3. Effects Lighting

1. *Base Lighting* is a uniform, wide distribution of low intensity illumination which covers the set, and may be provided with either incandescent floodlights or fluorescent lamps.

Where fluorescent equipment is used for base illumination, a No. 6 Wratten filter should be used on the camera lens to correct for color rendition.

2. *Accent Lighting* includes key lighting, modeling lights, back lighting, and fill lighting.

Key lighting is principal illumination which falls on a subject from light coming through a window, an open door, or fireplace, or at any point where action takes place. Spotlights with accessories and effects lighting devices are engaged to produce this key light.

Modeling lights are used to enhance the appearance of a subject, and for creating artistic effects. For this purpose, Fresnel lens spotlights, equipped with adjustable blinds and diffusers, are used.

Back light is used to create the illusion of separation between the subject and the background, and to produce the artistic effects such as glistening highlights from the hair. Fresnel lens spotlights, with "barn doors" to control the spill light or shape the beam pattern, are used for this application. Strip lights are also employed to flood the background or side walls as needed.

Full light is employed to add more light to portions of the set to bring out more detail in the shadows, or to add some highly diffused light on the face of a subject opposite to a key light source. Narrow beam floodlights equipped with diffusers, or Fresnel lens spotlights with diffusers, are engaged for this purpose.

3. *Effects Lighting* — An important part of the interest in a television performance is maintained by the special ighting effects which are introduced to simulate realistic scenes. This is particularly true in the case of firelight, cloud effects, and window

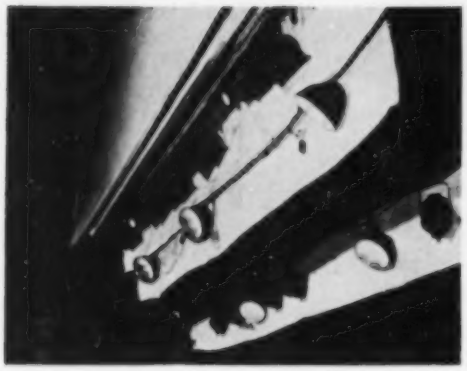

TABLE I.—Incident Light Required for RCA Image Orthicon 5820.

Lens Stop	Incident Light
f:1.9	2-4 Footcandles
2.8	4-8
3.5	6-12
*5.6	16-32
*8	32-64
11	60-120
16	120-240

*Normally Used.

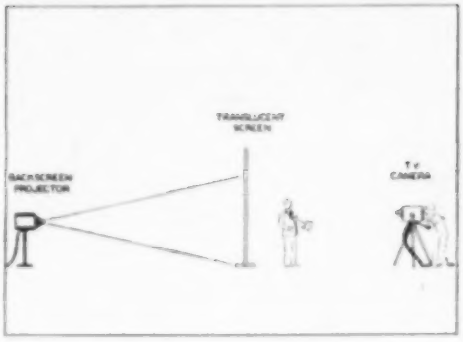

Figure 10. (Top) Floods and spotlights concealed by drop curtains and suspended over front of stage area. Figure 11. (Center) Schematic view showing application of rear-screen projection technique. Figure 12. (Bottom) Pantograph device permits raising or lowering of fixtures as well as horizontal or vertical adjustments.

light created by equipment previously described. More recently, a technique was borrowed from the motion picture studios in simulating backgrounds and moving scenery as from a train window, the back of a car, etc., by using rear screen projection. Fig. 11 indicates how this is done. Care must be exercised in relation to perspective; distance between the live subject and the screen to avoid unwanted shadows; and the amount of front light to avoid washing out the projected picture. If motion pictures are used, the problem of synchronizing the frame frequency of the projector to the television camera must also be overcome. Fortunately, new equipment has been built which has satisfactorily solved this difficulty. It is obvious how outdoor settings can be quickly and economically reproduced. When stills can be used, the cost of backgrounds has also been sharply reduced and the variety of settings increased in proportion to the number of slides available.

Conclusion

With an accumulation of experience and knowledge of the requirements, television studio lighting techniques have reached a point where definitely planned schemes and practices can be recommended to produce artistic effects and good pictures. The best results, however, can be obtained only through imagination and originality in applying the fundamental principles.

It may be well to point out that the final criterion in appraising studio lighting cannot be judged by results obtained on the home television receiver alone. The studio-to-home span includes not only a well-lighted studio scene, but also properly-functioning transmission facilities, and a good quality, properly-adjusted home receiver and antenna. Good pictures are the result of efforts on the part of all of those who form the chain of facilities which link the studio scene to the television receiver.

Lighting a Telephone Room

LIGHTING OBJECTIVE: To provide illumination in a windowless telephone switchboard room.

Installation at Consolidated Edison Company of New York, Inc. 4 Irving Place, New York City; lighting designed by H. J. Peters.

General Information: A ten-position telephone switchboard is located in a 26' x 38' room with an 8'5" ceiling. Surface characteristics are as follows:

Ceiling	white acoustical tile	75% RF
Walls	sea foam green	35% RF
Trim	dark green	9% RF
Floor	mottled grey rubber tile	40% RF
Switchboard		
Cabinet	mahogany	18% RF
Horizontal Shelf	green (glass covered)	20% RF
Jack Panel		13% RF

The Telephone Company specified the following footcandle levels for the board:

Key Shelf	minimum 5	maximum 10
Jack Panel	minimum 3	maximum 7

Installation: Six recessed louvered troffers (Frink Corp. #10-248L) each containing two 40-watt soft-white fluorescent lamps are mounted on centers 6 feet apart and 3 feet from the top edge of the board. Five additional similar units are installed over the supervisors' desks. The louver cut-off is 45 degrees crosswise and 30 degrees lengthwise. All louvers are painted a dark matte gray to minimize the brightness contrasts between the louvers and adjacent ceiling areas.

(over)

A.I.A. File No. 31/14

Eight 96-inch and three 72-inch 4500K slimline lamps operated at 120 ma are installed in asymmetric specular anodized aluminum reflectors (similar to Day-Brite #49142-CO) in a 20-inch wide recess in the ceiling along the edges of the room to soften the harsh effect of downlighting with no windows. Plastic egg-crate louvers shield the lamps in the front section of the perimeter recess from the eyes of persons entering the room.

Illumination readings ten months after installation were as follows:

Jack Panel	7 ft-c
Key Shelf	
Operator in position	10 ft-c
Operator not in position	15 ft-c

Brightnesses are indicated below:

Jack Panel	0.8 ft-L
Horizontal Shelf	1.8 ft-L
Plug Board	0.5 ft-L
Floor	5 ft-L
Walls	
Top	15 ft-L
Center	6 ft-L
Ceiling	2 ft-L
Luminaires	
Parallel to lamps	
30° to horizontal	74 ft-L
45° to horizontal	140 ft-L
Perpendicular to lamps	
30° to horizontal	50 ft-L
45° to horizontal	68 ft-L

The bright side walls are not within the operators' normal working field of view.

Lighting data submitted by J. C. Murtha and H. J. Peters, Consolidated Edison Company of New York, Inc., as an illustration of good lighting practice and to aid in the design of similar installations.

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Acrylic Plastic for Light Control

By DR. ORVILLE L. PIERSON

SO MANY new developments in the lighting art are attributable to the relatively recent availability of plastics, a short review of some of their characteristics for light control might well be in order. Wall-to-wall luminous ceilings of plastic materials have furthered this technique for many areas. Store fronts, billboards and signs glow all over with the same colors and appearances as they have by daylight. Plastic street light globes are saving replacement costs in the worst neighborhoods, while better daylighting is being achieved by the use of plastic skylights and diffused glazing materials.

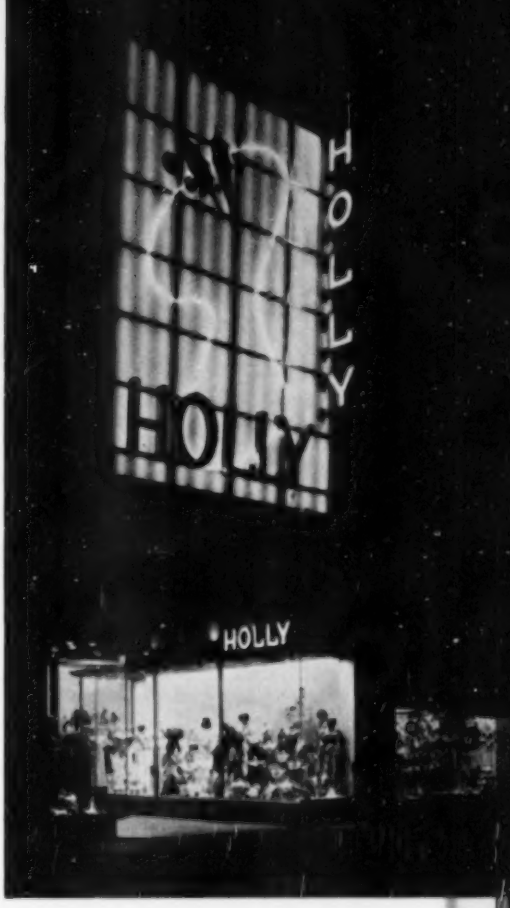
Among the plastics, acrylic resin is a relative newcomer, having been introduced in the United States about 1937. Its development has been of importance to lighting engineers since it is available either clear or with any degree of diffusing power or color, as desired. In addition, it offers shatter resistance, light weight, ease of forming, and availability in large size sheets, or molded or extruded form.

Acrylic plastic is a thermoplastic material When heated above a given temperature it softens sufficiently to permit its being molded or formed into almost any shape which it retains when cooled. If again heated to the same temperature, it will again soften, permitting re-forming of the part if desired. This property places some limits on the maximum service temperature at which it may be used, but in general leads to no difficulty when the applications are properly engineered.

When heated to the 300-350F range, the material becomes flexible and elastic, somewhat similar to a piece of rather soft gum rubber sheeting. In this stage it may be stretched into virtually any desired shape and upon cooling will retain that shape.

Certain engineering considerations should be observed in working out an installation. Perhaps most important of these is to design the shape in such a fashion that the forming tends to rigidize the part. For example, it is desirable to use corrugated sheet rather than flat sheet for a luminous ceiling. A second engineering consideration is the rather large thermal expansion characteristic of almost all plastic materials. The material expands approximately 10 times as much as the common building materials. It is rather simple to make proper provision for this expansion in installation, but it is a factor which must be constantly borne in mind.

In the clear form the light transmission of acrylic plastic sheets is 92 per cent, the losses being limited to about four per cent reflection loss at each surface. Its colorless characteristic has lent itself well for the piping of light or for edge lighting. With such a crystal-clear base material, a complete spectrum of colors, either transparent or translucent, is



Designed by Morris Lapidus of New York, this beautiful luminous storefront in Baton Rouge, La., was created by backlighting large panels of corrugated white acrylic plastic. Weather-resistant, light weight and of high impact strength, the acrylic plastic covers a 20-by-25-foot area. The interesting luminosity pattern is achieved with rows of neon behind the facade. Red and green plastic is used for holly leaves and berries mounted against the glowing acrylic background.

Author: Head of Plexiglas Design and Fabrication Laboratory, Rohm & Haas Company, Philadelphia, Pa.

Nineteen curved acrylic plastic panels, eight feet high and four feet wide, form a spectacular storefront at this supermarket in Atlantic City, N. J. Made of tan-colored material and formed to a heavy-ribbed design, the panels are backlighted by fluorescent lamps so that the entire upper facade of the building represents a brightly glowing appearance at night.

possible. Of even more importance to lighting engineers, it is possible to make a translucent material by the addition of a very small quantity of another transparent material having a slightly different index of refraction. This additive is incompatible with the acrylic plastic, and so disperses uniformly throughout the plastic sheets as an infinite number of discrete particles. The refraction taking place as the light passes from one material to another produces an excellent diffusion of the light without absorbing any of it.

It is not the perfect material, of course. However, two of its shortcomings are readily overcome. Where the build-up of static electricity may attract dust to the surface of the plastic, application of an anti-static wax will generally cure the trouble. The danger of scratching its surfaces is not very serious in the lighting field, particularly since most lighting parts are made of the translucent or patterned plastic which does not show scratches. As a corollary to scratching, acrylic is easily repolished.

Acrylic is classified by the Underwriters' Laboratories as a slow burning material comparable to hardwood and as such has been approved by them for use in electric signs, luminaires and lighting applications.

One rather unique application is the use of clear acrylic resin for the making of mirrored reflectors. Here the material is formed to the desired contour and the outside or second surface of the transparent sheet is silvered. A second sheet is similarly formed and fitted down over the first to provide a protective covering. The resultant reflectors are light in weight, have a silvering permanently protected and are shatter resistant. Clear acrylic has also been used in the making of shields for vaporproof lights for mines as well as protective sheaths for the ubiquitous neon signs in the taproom windows.

Vandals have found plastic street lighting globes nearly impossible to break, even with half bricks or .22 rifles. Street lighting plastic globes may be used on gas lighting units and on electric units up to and including 6000 lumens sizes.

In addition to "daylight" conditions under luminous ceilings, acrylic plastic is finding application in the control of real dayight as well.

Still another use of acrylic plastic of interest to illuminating engineers has been a rapidly growing application in the advertising field. Signs of all types designed for interior illumination and ranging from the small point-of-sale sign to spectacular billboards with 30-foot long loaves of bread are being constructed of the material. Structurally, it is strong enough to withstand severe storms and ice, as has been proved by installations atop the Empire State Building and Mount Wilson.

Coffer lighting panels made of white translucent acrylic plastic set in the ceiling of the reception room of the Associated Fur Manufacturers office, New York City, provide excellent diffused lighting for the room and blend perfectly with the attractive decorative motif.

Development of A-C Fluorescent Lighting for New York City's Subway Cars

By E. W. BEGGS
H. W. GRAYBROOK

A special 600-volt d-c drive, 60-cycle a-c flywheel type motor-alternator mounted under each of the experimental cars provides uninterrupted a-c power with closely controlled voltage and frequency for fluorescent lighting. The momentum of the flywheel provides power to keep lamps lighted across the longest gaps in the third rail power system which, in addition to the relatively constant potential and frequency, permits the use of standard high output, high efficiency hot cathode fluorescent lamps and equipment. Blinking of the lights at crossovers is eliminated, the lighting level is practically constant, the number of fixtures and the power required per car is reduced, lamps start dependably in cold weather, cathode shadows at lamp ends are minimized, and the mercury drift which on d-c often causes one end of a lamp to dim is eliminated.

ON TUESDAY, September 20, 1949, the New York City Board of Transportation placed a new stainless steel subway train into passenger service. This new train was created to test out in practice certain improvements in car design and fabrication. One of the more important innovations is fluorescent lighting with the lamps operating on uninterrupted alternating current instead of on direct current from the third rail as is now done and, of course, this is the one of most interest to illuminating engineers.

Fluorescent lamps were developed for operation on alternating current and they operate most efficiently and effectively on that type of electric power. A motor-alternator for each car would be the logical device to provide a-c power for fluorescent lamps. An analysis showed that by adding a flywheel, the lamps would stay lighted as the train passed over gaps in the third rail power system. This eliminated the blinking of the car lights and permitted the use of standard high efficiency, high output hot cathode fluorescent lamps. Also, with close control of voltage and frequency, the level of lighting in the car would stay about constant, regardless of line voltage, and ordinary commercial two-lamp lead-lag ballasts could be used with good balance of lamp output without danger of ballast failure due to overheating.

Such an a-c system would also insure dependable cold weather lamp starting and, of course, it would eliminate d-c mercury drift which causes one end of a lamp to become dim. The use of standard hot cathode lamps and equipment would reduce the number of lamps and fixtures and the amount of power required for a given footcandle level in the car than with the d-c system and would improve the appearance of the lighting by reducing the length of the dead end at the lamp cathode.

Because of all the advantages offered by such a device, development of a flywheel motor-alternator to provide uninterrupted and well controlled 60-cycle a-c power was authorized for the experimental train in June, 1947. After two years of study, extensive test work and trial, the present Westinghouse type XF-23A machines were produced and installed. Each detail of design was worked out to meet the special requirements of the New York subway system in collaboration with the car engineers of the Board of Transportation.

A paper presented at the National Technical Conference of the Illuminating Engineering Society, Pasadena, California, August 21-24, 1950. Authors: Commercial Engineering Dept., Westinghouse Lamp Division, Bloomfield, N. J. and Transportation Engineer, Westinghouse Electric Corp., East Pittsburgh, Pa., respectively.

Power Continuity

The track layout of the New York subway requires frequent gaps in the third rail system resulting in an interruption of the power to each car about 35 times per operating hour. The number and size of the gaps and the speed of the trains vary considerably throughout the subway system, but in general the interruptions have a duration of less than one second. A very few are as long as 10 seconds, occurring chiefly at the end of the line and on rare occasions when a car comes to a stop between contact points and then, of course, the duration is considerable.

Table I lists the approximate number and dura-

Figure 1. Five-car section of experimental train. Flywheel motor generators and control box mounted beneath car floor.

tion of power interruptions found in a survey of the three divisions. These values were used in developing the a-c generating equipment for the experimental train.

TABLE I.
All Time Values in Seconds

Division	Independent	I.R.T.	B.M.T.
Average Number of Interruptions/ Operating Hour	37	28	40
Average Duration	0.75	0.5	1.0
Maximum Duration (excluding occasional stops in crossovers)	4.5	4.5	10
Minimum Duration	0.05	0.06	0.07
Number of Interruptions/Hour Exceeding 4.5 Seconds	1	1	2

Tests run on banks of fluorescent lamps operating on two-lamp lead-lag ballasts on an experimental flywheel generator showed that as the machine slows down the lag lamps are the first to go out. They are followed at a slightly lower voltage by the lamps on the lead leg of the ballasts. "Drop out" is, of course, determined by voltage and not by frequency. It is affected by the design of the ballasts and the character of the lamps and, to some extent, by ambient temperatures and other conditions.

With 72" T-8 slimline lamps, which are used in these cars, "drop out" occurred at ordinary room temperatures at 64.5 down to 61.0 volts on lag and at 60 down to 53 volts on lead circuits. The flywheel size, shape and speed were computed from the average kilowatt-hour requirements of the lamps and ballasts from normal volts down to these "drop out" voltage values found in the tests.

The specifications set up by the Board of Transportation required maintenance of the lighting over a gap with a duration of 10 seconds. The flywheel used weighs 142 pounds and has a diameter of 18⅝ inches. It runs at a normal speed of 3600 rpm and has sufficient inertia energy stored up to yield 24.5 kilowatt-seconds of electrical energy while the speed of the set drops to 3000 rpm. On block tests and actual tests in the cars under normal conditions, the lights stay on for about 25 seconds.

Figure 2. Interior view showing two continuous rows of dust tight fixtures per car with 72" T-8 hot cathode slimline lamps.

Figure 3. 4.2 KVA Westinghouse Type XF-23A motor-alternator on test. Flywheel housing is shown at the right.

Voltage and Frequency

The traction power is direct current and is supplied at nominally 600 volts. The range of voltage is appreciable and may drop as low as 400 and rise as high as 750 volts. This results in variations in the light output of the lamps with the three lighting systems now in use as shown in Fig. 4.

The variation of light output that is obtained with incandescent lamps operated off the d-c power line is proportional to the voltage and varies about 3½ per cent for each one per cent change in voltage. The lamps go out entirely when the power is interrupted.

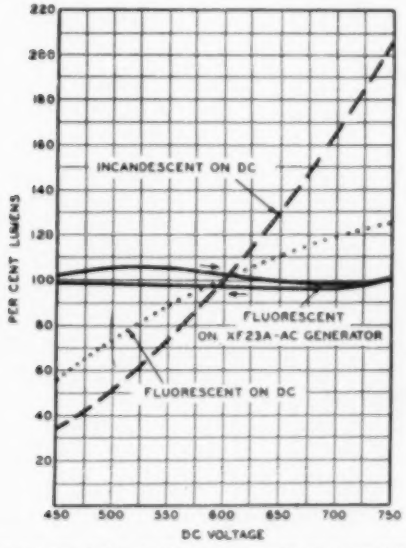


Figure 4. Variation in light output with rise and fall of line voltage.

Fluorescent lamps require the resistance type of ballast for operation on d-c. With the 72" T-8 special lamps and special ballasts used, the lumen output rises and falls with the d-c line voltage as shown by about 1½ per cent for each one per cent change up or down in volts. Also, of course, the lights go out entirely at gaps in the third rail system.

With the type XF-23A alternator developed for the Board of Transportation, the output volts and frequency are controlled to close limits and they tend to rise and fall together. With standard two-lamp lead-lag ballasts, they compensate for each other almost fully so light output is nearly constant as shown in the curves in Fig. 4. The values shown were obtained with standard 72" T-8 slimline lamps as the line volts were raised from the minimum to the maximum and then lowered. In service, the light level is held within the hysteresis pattern shown.

Ambient Temperature

Railroad operators, of course, want their lamps to light up under all conditions of voltage and tem-

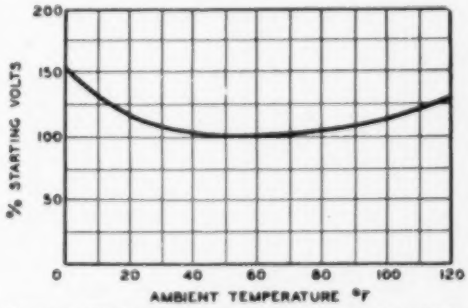


Figure 5. Slimline fluorescent lamps will start dependably at low temperatures if the starting voltage is increased.

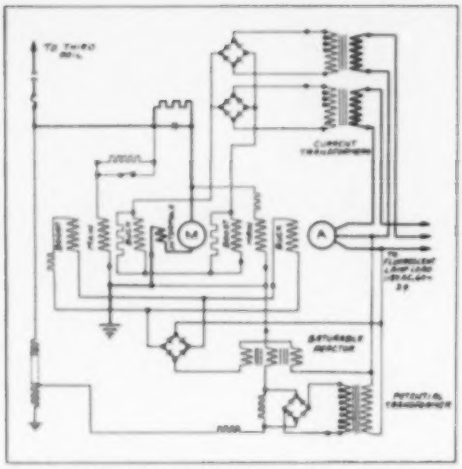


Figure 6. Simplified diagram of XF-23A motor-alternator showing essential electrical parts for voltage and frequency control.

perature encountered. Incandescent lamps meet this requirement well, but fluorescent systems are somewhat temperature sensitive. Naturally, a public conveyance should not run cold or the passengers will be uncomfortable, but light is sometimes needed at low ambient temperatures for maintenance operation of cars in the yards in winter.

Whereas the d-c potential available for lamp starting is limited to that available for traction, an a-c generator has been devised to provide normal potential even with a low traction voltage. Also, the peaks of a-c voltage waves aid fluorescent lamp starting, so with alternating current the low temperature starting problems are fundamentally less than with direct current. Furthermore, with alternating current, it is practical to use special ballasts of high open circuit voltage or to provide a cold weather voltage booster transformer which could be designed for any ambient condition whatever. One such device per car would be adequate and could be arranged for simple manual push button control or, if desired, could be fully automatic.

Dependable low temperature operation can thus be obtained for any range of conditions required if alternating current is available for the fluorescent lighting. If car temperatures only occasionally run below freezing, as is the case in New York, then the present type XF-23A equipment would seem adequate. With this flywheel generator, no lamp starting troubles were encountered during the 1949-1950 winter season. However, where cars must be stored in the open at night and in winter temperatures that are extremely low, then voltage boosters or high voltage ballasts may be found necessary.

Fig. 5 shows the relative open circuit voltages required to start the standard 72" T-8 slimline fluorescent lamps over a range of ambient temperatures that may be encountered. From this, it is evident that by increasing the potential at the lamp by about 50 per cent, the lamps will start as dependably at 0°F as they do at 50°F. Once they are started, they will ordinarily stay lighted down to low ambient temperatures if they are not directly exposed to strong cold drafts.

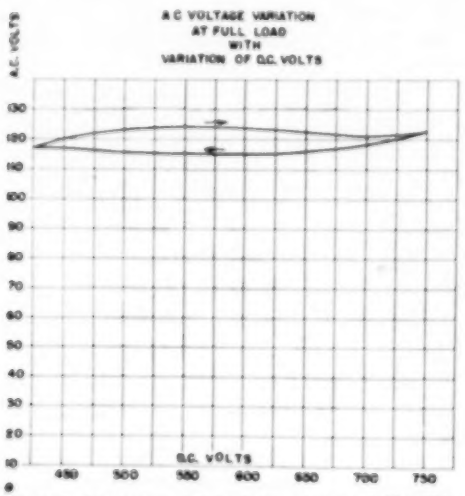


Figure 7. At constant full load the voltage is held within Narrow limits, centering at 120 volts.

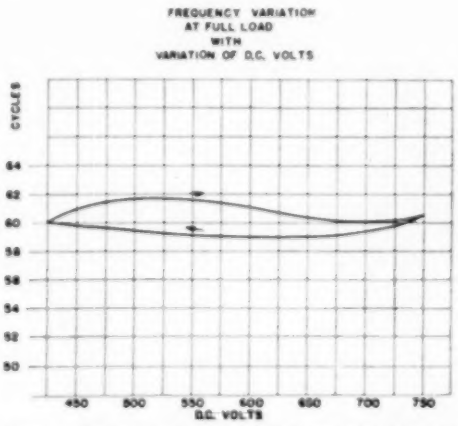


Figure 8. Frequency variation is small and parallels voltage pattern which minimizes variation in illumination.

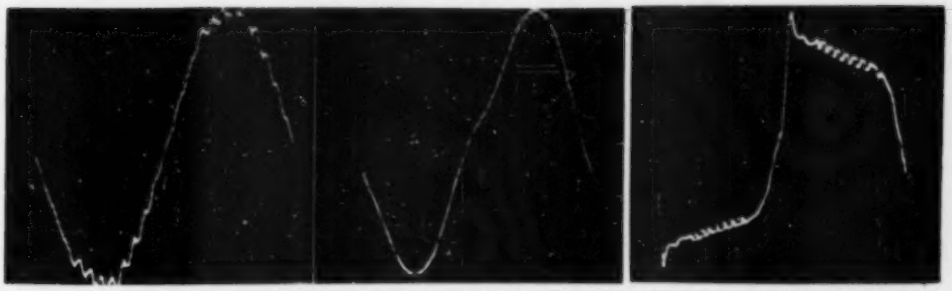


Figure 9. (Left) Alternator volts under full load. Figure 10. (Center) Wave form of current through fluorescent lamp. Figure 11. (Right) Fluorescent lamp volts through the cycle, showing normal wave form obtained.

Design Characteristics of Type XF-23A Alternator

The Westinghouse type XF-23A motor-alternator supplies the 118-volt, 60-cycle current for the fluorescent lights, and also for the precipitron equipment, the bactericidal lamps, the battery chargers and other a-c apparatus on the car. All a-c loads other than the lighting are dropped after one second of gap operation in order to conserve the energy stored in the flywheel.

The control of the output voltage and the frequency of the motor-alternator is obtained by controlling the speed of the motor and by providing a suitable field strength in the alternator. Speed regulation and field strength control are achieved by means of auxiliary boosting and bucking fields in both the motor and alternator. These auxiliary fields are energized with direct current from the alternator through rectifiers. Fig. 6 shows the schematic arrangement of the principal elements of the machine. The regulating control is static, so there is no need for further adjustments after it is once installed and regulated.

Figs. 7 and 8 show the small variations that exist in the a-c voltage and frequency over the range of d-c third rail voltage involved. Fig. 9 shows the sinusoidal wave form of the alternator volts and Fig. 10 shows the good ratio of peak to rms values of lamp current. Lamp volts in operation, Fig. 11, follows the normal pattern through the full cycle.

Conclusion

Uninterrupted 60-cycle alternating current with good wave form and well controlled voltage and frequency can now be provided for railway cars where 600-volt d-c traction power is available even with wide variations in d-c potential and with frequent and somewhat prolonged interruptions in the power supply to the car. With such a-c power available, standard fluorescent lamps and equipment provide light at a relatively constant level and give the satisfactory trouble-free type of operation obtained in ordinary commercial or industrial lighting service. The type XF-23A machine has revealed the value of such a continuous flow of a-c power for this application and extended use is expected of this type of equipment where similar conditions are involved.

"Proceedings" Issue

A limited quantity of complete sets of all of the 1950 Conference papers in full, in one cover-bound volume, will be available from the Publications Office of I.E.S. Headquarters, as a "Proceedings" issue of the 1950 National Technical Conference. Price is $2.00 per set. Not all of the Conference papers are at present scheduled for publication in full in ILLUMINATING ENGINEERING, the Proceedings issue being made available for reference on the complete program.

Lighting a Roller Skating Rink

By E. W. HALTEMAN

THE little town of Freemansburg, Pa., (pop. 1500) has one of the most interesting lighting jobs I have ever been called on to plan. It's a luxurious roller skating rink called the "Skadium." Built on quonset design, it is 125 feet by 125 feet in size.

In so small a community, patrons must be attracted from miles around, so traffic-stopping lighting, in color, is featured for the exterior.

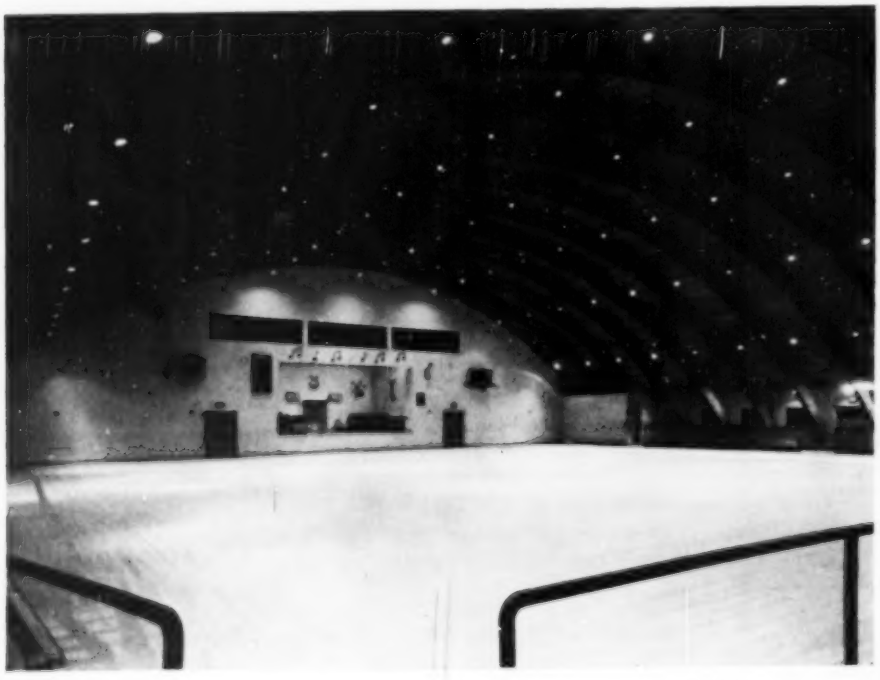
In planning the interior illumination, a major problem was the ceiling curvature — 12 feet high at the outer walls, to 32 feet at the center arch. Shielded units were in order, to avoid glare, and a bell-shaped hood type luminaire was installed, with straight rigid hangers. Overall suspension is 24 inches to 27 inches from the ceiling.

Since skaters are of all ages and degrees of proficiency, good illumination was called for. Approximately eight footcandles is provided from white R-40 floods. Red, green, blue, ruby, and amber R-40 lamps provide color lighting for atmosphere, with favorable results.

To achieve flexibility, 45-ampere a-c magnetic starters are employed to simplify the lighting and wiring circuits. Lighting in the main auditorium is controlled by six starters, with luminaires so arranged that the illumination level may be one to eight footcandles. Small diameter wire was used between control equipments and switches.

The restaurant (not shown) features cove lighting, with louverall panels over the counter areas. Recessed fluorescent lighting has been used for the entrance, and circline fluorescent in the check room. Exterior lighting uses 15 mm tubing, with 12 mm tubing for the sign lighting, both 30 ma, 7500-volt secondary.

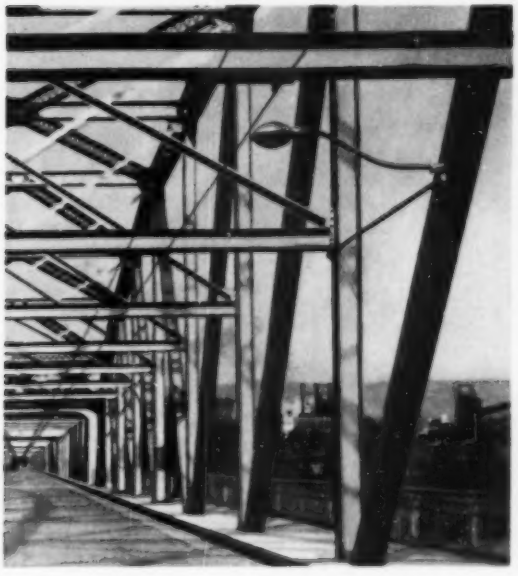
Winning installation in the contest for "My Most Interesting Lighting Job" conducted by the Eastern Pennsylvania Chapter, presented at the East Central Regional Conference. Mr. Halteman is with the Pennsylvania Power & Light Co., Bethlehem, Pa.



Lighting a Bridge

LIGHTING OBJECTIVE: To provide an average maintained illumination of 1.0 footcandle across the roadway without glare and confusing shadows, with sufficient sidewalk lighting for pedestrians.

Installation on Carey Avenue Bridge over Susquehanna River connecting the Borough of Plymouth and Hanover Township, just south of Wilkes Barre, Pennsylvania.



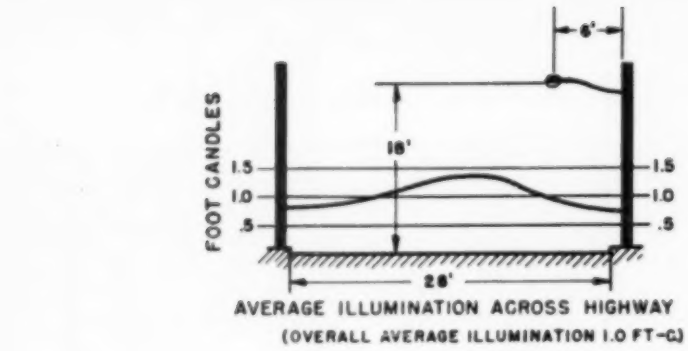
General Information: The bridge is 1887 feet long with overhead trusses giving a roadway clearance of 16 feet. The bridge deck is concrete with open gutter design. Roadway is 28 feet wide. All structural members are aluminum-finished.

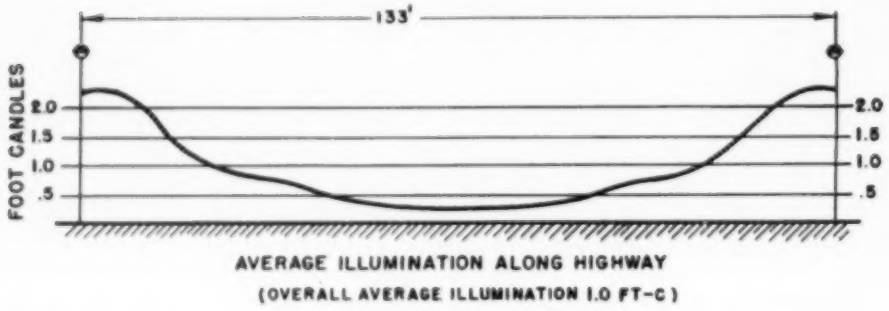
Installation: Eighteen (14 on the bridge proper and two on each approach) Westinghouse Type OV-20 (IES Type II) luminaires employing C-H5 11250-lumen mercury vapor lamps are installed on 6-foot upsweep brackets located on the diagonal uprights to provide maximum mounting height and strategically positioned to use overhead trusses as a valance. (There is only one luminaire, and that above the normal line of vision, visible at any given point).* Average linear spacing is 133 feet, and the light center is 18

*Night view photograph taken directly underneath a luminaire.

(over)

A.I.A. File No. 31/11





feet above the roadway, five feet out over the roadway. The electrical distribution system is multiple, the 115/230 volt ballasts being located in handholes in the sidewalk. All wiring is in metal conduit.

Observers feel that this roadway is more effectively illuminated by night than by day since sunlight shining through the structure causes a pattern of shadows. Glare is negligible and although luminaires are hidden from view there is no major interference with their maximum beams.

Lighting data submitted by Luzerne County Gas & Electric Corporation, Kingston, Pennsylvania as an effective solution to a bridge lighting problem and to aid in the design of similar installations.

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Results of Two Decades of Carbon Arc Research

By WOLFGANG FINKELNBURG

THE CARBON arc is generally known to have been the first electric light source. Discovered 150 years ago, it has actually been used as a light source for more than one century, and few sources have had the benefit of so much scientific interest and study. No wonder, therefore, that the majority of physicists and illuminating engineers were convinced that the carbon arc had ceased to be an interesting physical and technological problem when, about two decades ago, it yielded its last positions in city and factory to more modern lamps, and thus literally disappeared from the public eye. It is quite a surprise even to most illuminating engineers to learn that resumed carbon arc research, combined with our modern knowledge of atomic and electronic processes in gas discharges has led, in the last two decades, to the development of a carbon arc light source which in every respect is far superior to the old carbon arc.[1] This high-intensity carbon arc, discovered four decades ago by H. Beck in Germany, still plays a decisive role in the whole motion picture industry,[2] from the studio illumination to the projection in virtually every movie theatre and, last but not least, as the light source for all large searchlights and a number of special scientific and technological high-intensity applications.[3] The modern carbon arc holds this unique position, in spite of the repeated attacks of more recently developed light sources such as the high pressure mercury arc lamps because it is, and apparently will be for quite some time to come, by far the brightest, most powerful, most sun-like white light source in existence. Moreover, it is in the process of catching, to an ever increasing extent, the eye of physicists, chemists and engineers as a source of the highest temperatures which can be produced continually on earth, so that it can be predicted with a great deal of certainty that the high-current carbon arc will play an important role in a slowly advancing high-temperature technology.

What is this high-current carbon arc, as we physicists call it, or high-intensity arc, as the illuminating and motion picture engineers call this modern form of the carbon arc, and what are its essential differences from the common low-current carbon arc?

The light source of the normal low-current carbon arc is the incandescent solid carbon of the positive crater. With a temperature of approximately 4000K, this crater has a brightness which ranges from 140 to a maximum of approximately 180 candles/mm^2. In the high-intensity carbon arc, on the other hand, the incandescent solid crater plays a comparatively minor role. From 70 to 90 per cent of the light radiation, depending on the anodic current density, is emitted by a highly incandescent, brilliantly bright and white vapor cloud which, with a temperature between 6000K and 8000K, emanates from the positive crater and forms the so-called positive flame, anode flame or tail flame which is the characteristic phenomenon of every high-current carbon arc. (Fig. 1). It originates from the evaporation of cerium compounds of the core of the positive crater.[3]

Figure 1. Photograph of a high-intensity arc (high-current carbon arc).

A paper presented at the I.E.S. Cleveland Technical Forum April 24, 1950. The author is a consultant physicist in the Engineer Research and Development Laboratories, Fort Belvoir, Virginia.

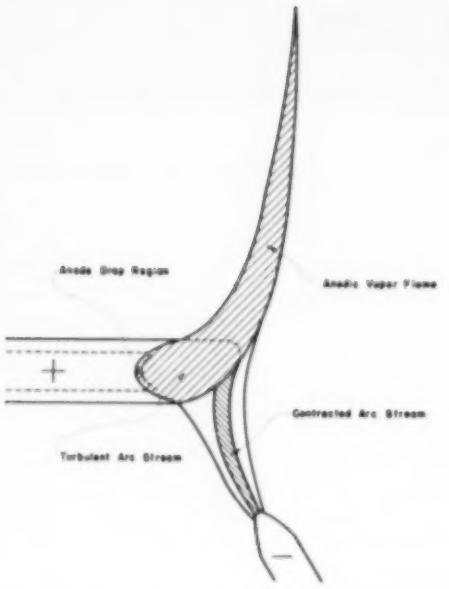

Figure 2. Schematic drawing of a high-current carbon arc with indication of the theoretically important arc regions.

There is a second distinction between the old low-current arc and the modern high-current carbon arc. At currents above 100 amperes, the normally diffuse and expanded arc stream seems to contract into a narrow, bluish-white column which we call the contracted high-current arc stream (Fig 2). Because its temperature is above 10,000K, this phenomenon is of utmost importance for the physicist. It is of interest, moreover, for the illuminating engineer also, because the understanding and control of this arc stream mechanism is prerequisite for the achievement of a steady high-current arc, as we shall see.

A few data may indicate what has been achieved at present. The brightness of the positive crater (including the vapor cloud in front of it) has been increased up to a maximum of 2000 candles/mm^2 and thus exceeds that of the sun by as much as 20 per cent. The total light efficiency of the high-intensity arc, including the positive flame, ranges from 60 to 90 lumens per watt, depending on the anodic current density and the kind of positive carbon used, and thus exceeds that of most other light sources considerably. The color of the high-intensity light is white with only a very slight inclination towards the blue-green which may be eliminated by further carbon improvement. The spectral energy distribution of the light in the whole visible and infrared spectral region is more similar to that of sun light than that of any other light source known so far. The high-current carbon arc, finally, is the most powerful single light source known. Arc lamps for steady operation have been developed for electric power inputs between one and 200 kw. Fig. 3 shows, as an example, a German searchlight lamp in which a rectangular positive carbon of 20 x 30 mm cross-section was operated at 1200 amps and 100 volts. Fig. 4 shows this lamp attached to the largest searchlight ever built to our knowledge. With a 120-inch mirror, it gave the amazing peak beam candlepower of nine billion.

We believe that these achievements as well as all future developments depend essentially on the cooperation between fundamental arc research and skillful engineering. A survey of the aims of carbon arc development may prove this point. What we want to obtain is:

(a) highest brightness and uniformity of the positive crater

(b) best possible steadiness of the light

(c) automatic operation of the arc lamp over periods of many hours.

Translated into the language of the physicist this means:

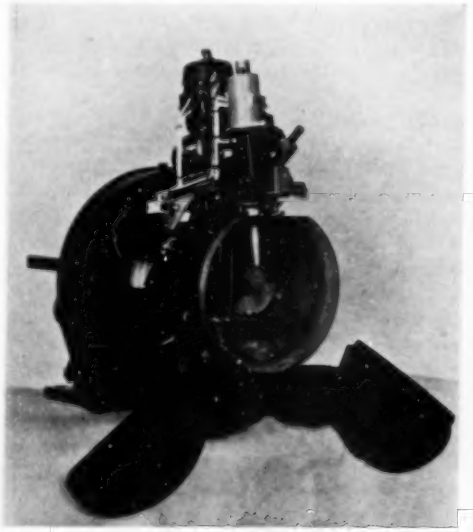

Figure 3. German searchlight lamp (built by Siemens-Schuckert, Nuremberg) operating rectangular 20 x 30 mm positive carbons at 1200 amperes and 100 volts. Rotating negative carbon points downward. The positive flame is sucked into nozzle which is visible at lower end of arc chamber.

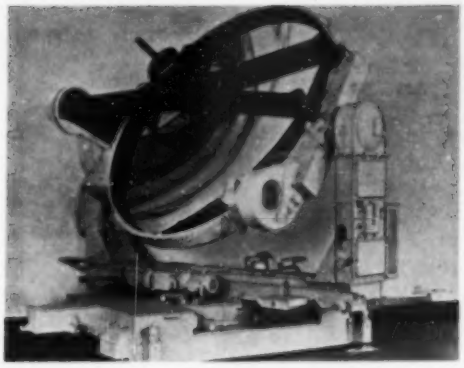

Figure 4. German searchlight (Siemens-Schuckert) with 1200-ampere arc lamp (Fig. 3) and 120-inch mirror, giving a peak beam candlepower of 9 billion.

(a) We have to know how to manufacture positive carbons which will stand the highest possible current density and contain, in suitable compounds, atoms which, by their atomic properties, cause the arc to produce the highest possible temperature in the positive crater vapor and which, when excited by this high temperature, emit a maximum amount of white light. Furthermore, the brilliant vapor cloud, produced by evaporation of these carbons, has to be influenced in its shape so as to cover the whole crater uniformly.

(b) In order to achieve good light steadiness, a very smooth evaporation of the positive core material is required, without any explosive micro-eruptions of vapor even at the highest current density, and a very steady flow of the electrons from the arc stream through the positive vapor cloud into the positive crater.

(c) The feed mechanism of the automatic arc lamps has to be developed so that it allows uninterrupted operation for the required length of time in spite of the large consumption of the carbons, necessarily connected with very high brightness.

The carbon manufacturers, aided by systematic research of their own and of other interested groups, have gone a long way towards the goal of manufacturing excellent high-intensity carbons outlined above. Starting from a purely empirical basis, they had to take into account more and more atomic, chemical, structural and technological facts and requirements, derived from our increasing knowledge of what is going on in the positive crater, particularly how the luminous vapor is produced and heated up. Chemical, electric, spectroscopic, X-ray and X-ray diffraction studies of the carbons and their core compounds have helped in the improvement of modern high-intensity carbons just as much as have the studies of the arc mechanism proper. As the energy dissipated in the different arc regions is the product of the current density times the potentional drop in that region, we believe that an accurate knowledge of the potential distribution in and in front of the positive crater (as well as in the arc stream) is important for the understanding of the mechanism of vapor production and vapor heating. Recently, we have made good progress at Fort Belvoir in this direction by oscillagraphic potential-probe measurements.

We know from all our investigations that the current of electrons, accelerated by the potential drop in the positive crater and then flowing into the positive carbon electrode, transfers to it the energy required for its vaporization, and heats up the vapor stream in the crater to its high temperature and brightness.

As the vapor temperature in the crater is one of the most important data in the arc, we have tried to measure it, in its dependence on the arc parameters, by different methods with fairly good success.[1] Additional theoretical considerations have taught us, in agreement with the experimental results, how the crater temperature, and with it the crater brightness, depends on atomic properties, in particular on the excitation and ionization energies of the vapor atoms. This knowledge has helped in eliminating unfavorable elements from the core material.

Simultaneously with the researchers of the National Carbon Company we have found, furthermore, that a suitable positive carbon, if effectively cooled by water-cooled metal jaws very close to its burning end, not only can stand a much higher current and thus give a higher maximum brightness and light steadiness, but simultaneously is consumed at a considerably smaller rate than an uncooled carbon whose internal mechanical structure is loosened up by the high temperature, before it comes into the arc.[4]

In order to improve the brightness uniformity over the crater, if possible combined with an addi-

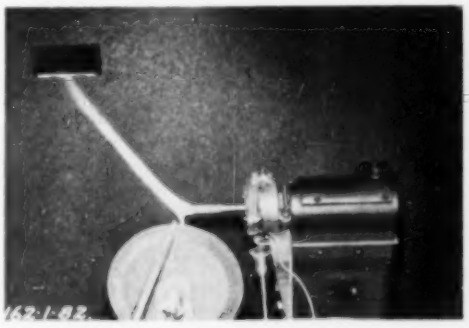

Figure 5. Experimental 200-ampere arc lamp with rotating negative disk, developed 1949 at ERDL, Fort Belvoir.

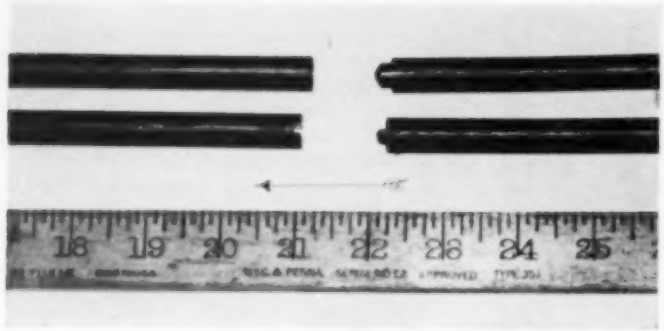

Figure 6. Machined joints of 11 mm searchlight carbons for use in searchlight lamp with automatic carbon joining. ERDL, Fort Belvoir, Va., 1949.

tional gain in absolute brightness, the natural flow of the brilliant vapor from the crater into the positive flame has to be modified in such a way that a suitably shaped vapor cloud of sufficient thickness and density is formed in front of the positive crater. This can be done with good success by means of external magnetic fields, though only one attempt at a systematic study of this problem has been published, by the author's group.[1] Gretener, in Switzerland, has tried to achieve the same objective, also with good success, by a combination of a magnetic field and an annular mechanical air stream. Comparisons of lamps with and without this air-stream stabilization are still missing, however.

We mentioned above that the production of the brilliant vapor cloud is effected by the electrons entering the positive crater from the arc stream. It is evident, therefore, that a smooth and undisturbed flow of the arc-stream electrons into the crater is imperative for a steady and efficient arc. The relative position of the two electrodes and the best-suited arc length, both functions of the arc current, therefore are just as important for a steady arc as is a sufficient knowledge of the arc-stream mechanism, in order to keep the arc stream behavior under control. The phenomenon of the extremely unsteady "exploded arc," reported by British researchers as a special arc form,[5] is actually caused by insufficient control of the negative foot point of the arc stream at currents above 500 amperes. A thorough knowledge of the arc stream mechanism has enabled Guillery in Germany, by means of a stabilizing magnetic field and a simple trick in his carbon arrangement, to prevent this instability and thus to obtain an absolutely steady arc at least up to 2000 amperes.[1]

It has been outlined above that high crater brightness can be obtained only by production of an ample amount of luminous vapor, and this rapid vaporization implies a fast consumption of the positive carbon, ranging up to 50 inches per hour for very-high brightness arcs. Furthermore, good arc steadiness can be attained only by use of a comparatively thin negative carbon (8 mm diameter) which is consumed also at a fast rate at currents of 200 amperes or above.

This high consumption of both carbons in a very-high-brightness arc was generally considered a serious obstacle with regard to automatic, uninterrupted operation of such arc lamps for a period of several hours. We have overcome this difficulty by two innovations: the use of a negative disk instead of the customary negative red carbon, and the use of a magazine with automatic mechanism for joining consecutive positive carbons.

Negative graphite disks have been used already by the British workers in their attempts to control their "exploded arc," mentioned above, at currents above 1000 amperes, and by Gretener in one of his air-stabilized arc lamps. We use the negative disk (Fig. 5) with a new control mechanism developed in our Laboratories by L. R. Noffsinger. In the normal, unstabilized arc, the magnetic field of the arc's current drives the negative foot-point along the disk's rim away from the positive carbon. If in this motion the arc stream moves too far away from its most advantageous position, it makes contract with a metal probe and thus energizes the armature of an electric motor which then turns the disk against the direction of the arc's motion. The arc itself thus causes the correct rate of rotation of the negative disk, and this simple and very effective control device is evidently based on an understanding of the arc's natural motion in its own magnetic field. Our tests indicate that it takes approximately 20 hours to consume an eight-inch disk of one-quarter inch thickness down to five inches diameter. Fig. 5 shows an arc with negative disk and metal probe in an experimental lamp.

In order to insure continuous automatic operation of an arc in spite of 30 to 50 inches positive

carbon consumption per hour, we use a device by which one positive carbon after the other is automatically inserted from the magazine into the feed mechanism. The ends of the carbons are machined as visible from Fig. 6. For rotating carbons the slot joint has proved superior to the conical joint which, on the other hand, if not rotated, results in less disturbance of the arc while passing through it. After having been machined, the joints are coated with a cement which dries. When heated to about 250°C, in the lamp, the cement becomes sticky and solidifies at approximately 600°C, so that the two carbons are firmly joined when the joint emerges from the water-cooled jaws. Though all details of this mechanism have yet to be worked out from the engineering point of view, our tests have proved beyond any doubt that automatic uninterrupted operation of very-high-brightness carbon arc lamps is possible for periods of many hours at least.

The time may come, though we have good reason to believe it very far away, when the carbon arc may be replaced entirely, as a tool of illuminating engineering, by other light sources. If that time should come, however, the high-current carbon arc will have conquered, in our opinion, an important position in other fields. These possible applications are so fascinating that a few concluding remarks may be devoted to them.

The high-current carbon arc, namely, already is the source of the highest temperatures which can be produced continually and are easily accessible in the laboratory. For illuminating engineering purposes, we vaporize and heat cerium compounds, because cerium happens to give the kind of light we want to achieve. However, we are not limited in the choice of our cores. Moreover, our experiments seem to indicate that virtually every solid material, when introduced in a suitable manner into the core of the positive carbon, can be vaporized and heated to a temperature between 6000 and 8000K. In this highly activated state, the vapors may decompose or, conversely, react with other vapors or gases in many ways not known at present to the chemist who confines his interest to lower temperature ranges. In the contracted high-current arc stream, mentioned above, we can heat gases, as has been proved for the case of air, to temperatures between 10,000 and 12,000K, *i.e.* to twice that of the surface of the sun. We can not describe in detail, in what strange manner the properties of matter change at these high temperatures. As one example we mention that air, known as a good electric insulator at low temperatures, at 11,000K has an electric conductivity which is nearly equal to that of a metal. We have begun to use the high-current carbon arc for studying in detail the physical behavior of matter at these high temperatures.[6]

Carbon arc research seemed a closed field two decades ago. Nevertheless, resumption of research with modern means and modern physicochemical and atomic knowledge has not only given the physicist insight into a most interesting discharge mechanism, but has led to a tremendously improved, powerful and practical light source. Besides, it is leading to a future high-temperature technology. The high-current carbon arc thus has proved an interesting example for the unique interaction of basic scientific research and technological development.

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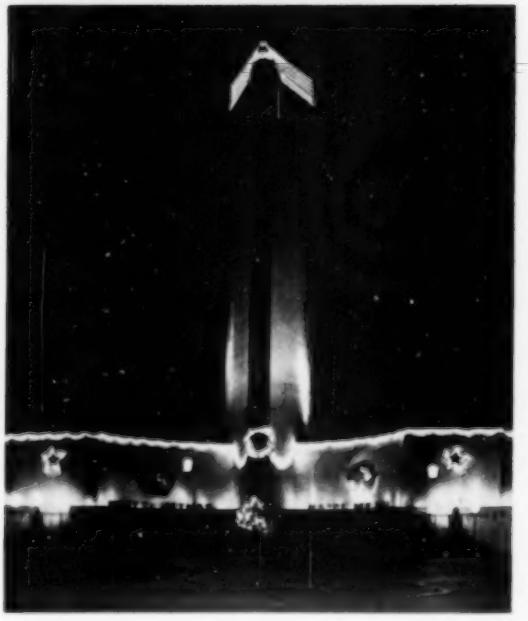
Erratum

I.E.S. Lighting Data Sheet No. 17-35, ILLUMINATING ENGINEERING, August 1950. Line 5, page 484 should read, "downlights shielded by concentric-ring louvers (manufactured by The Art Metal Company) . . ."

Christmas is Nationwide

Throughout the nation, lighting effects more than any other thing, make Christmas a community affair. These pictures, taken in the north, south, east and west, represent only a few of the lighting ideas developed for public display of the Season's Greetings.

Above—New York City greeted its millions with a 75-foot Norway spruce, sprayed white, and trimmed with plastic balls and thousands of colored lamps. At right—Tampa, Florida features a Christmas Card Lane sponsored by the Junior Chamber of Commerce.



In Denver, Colorado, above, a realty company greets passersby with floodlighted Nativity scenes. At right—A public building in Texas is trimmed and lighted for Christmas. Photographs courtesy of General Electric Co.

New Glass Developments in the Field of Illumination

By W. W. SHAVER

Recent developments have produced two new types of glass which have interesting possibilities for application in the lighting field. The 96 per cent silica Vycor brand glasses have unusual heat resistance opening up a field for the design of radiant energy sources with high output in very small outer envelopes. By using special graded glass seals, the transition is readily made from the 96 per cent silica glass to glasses normally used in lamp making, sealing directly to standard tungsten lead-in wires. The second type is photosensitive glass which affords a new photographic medium for a wide variety of applications. In lighting control a photosensitive opal glass is the base for new louvered panels used with various light sources.

GLASS HAS long been recognized as one of the oldest materials known to man, a material possessing unusual beauty in appearance and form but strictly limited in application by its inherent properties of mechanical and thermal fragility. However, advances in recent years in the field of glass composition, form of product and finishing treatment have completely changed the earlier concept of glass, as a vase or a window. The word "glass" has become the name of a class of engineering materials with a broad range of physical properties. How rapidly this change has come about is emphasized if we consider for a moment a condensed time scale in which the period from the earliest known man-made glass to the present day is reduced to a total of fifty years. On this basis the modern glass age began some two months ago and the principal development of the glasses discussed in this paper happened in the last two weeks.

Glasses can be made using practically all the elements in the atomic table except the rare gases so that the number of possible compositions is practically infinite. At the present time in the technical glass field some four hundred compositions are melted commercially and made into 35,000 products. Glass as an engineering material can be made in density lighter than cork, almost as heavy as iron; in range of hardness from amethyst to turquois; with controlled transmission and absorption of radiation in the infrared, visible, ultraviolet and X-ray regions of the spectrum; in mechanical strength, stronger than cast iron; in resistance to heat shock, from yellow heat to ice water. The two types of glass herein discussed are important new additions to this category of engineering materials.

High Silica Glasses

The Vycor brand 96 per cent silica glasses are made by a unique process[1, 2] which has been called the only new development in glass making since glass melting began. Alkali-borosilicate glasses are melted by conventional methods in a glass melting unit and then formed by pressing, blowing or drawing in the desired but oversized shape. The product may be finished by such operations as cutting, grinding or flame working if necessary, and then after subjecting it to a heat treatment somewhat above the annealing temperature, it is immersed in a dilute acid bath for a period of time depending on the wall thickness. In the heat treatment the glass separates into two phases, one of which is rich in boric oxide and acid soluble while the other phase is practically 96 per cent silica and quite insoluble. In the acid bath the soluble materials are leached out leaving a porous structure of 96 per cent silica composition. Thus the original glass has been transformed into a porus glass product of the same size and shape but weighing approximately one-third less and having a composition of 96 per cent silica. In this porous state, the glass is permeated with tiny sub-microscopic holes from 40- to 60-A in diameter (averaging 0.0000002") showing a slight opalescent appearance on drying. The porous glass is a very fine filter, so fine in fact that water in a porous glass beaker would penetrate so slowly that it would evaporate under low humidity conditions as rapidly as it came through. The holes are so numerous that one ounce of porous glass has an actual surface area of 1¼ acres. In this form it is a good dehydrating agent, like silica gel, and if handled with moist hands, it feels sticky. In the

A paper presented at the National Technical Conference of the Illuminating Engineering Society, Pasadena, California, August 21-24, 1950. Author: Research and Development Department, Corning Glass Works, Corning, N. Y.

next step in the process the porous glass article is heated to a high temperature causing shrinkage in all dimensions of some 14 per cent linearly while the holes close up and the glass becomes completely consolidated and impervious. Under proper control this shrinkage occurs with practically no change in shape so that by allowing for the predetermined shrinkage factor finished products can be made to desired dimensions. This final 96 per cent silica glass has properties comparable to those of fused silica as shown in Table I. The values for Pyrex brand chemical glass, Code 7740, are also given for the sake of comparison.

The advantage in the 96 per cent silica glasses over fused silica lies in the fact that products can be made by conventional glass forming methods using standard mold equipment and glass melting practices entirely impractical for fused silica, which melts and must be worked at temperatures well above the melting point of iron. Thus it is possible by this method to make a variety of products of intricate form and shape having approximately the characteristics of fused silica. For example a line of chemical laboratory beakers, crucibles and tubing is now on the market. The Vycor brand crucibles can be heated with an oxy-acetylene torch to yellow heat and then thrust against a cake of ice without fracture. In the same kind of a flame the glass melts with some difficulty, again like fused silica, which is only 150°C higher in softening temperature. The 96 per cent silica glasses are mechanically hard with a hardness approximately 7 on Mohs' scale and excellent chemical durability. The transmission for both visible and infrared radiation is shown in Fig. 1 for 96 per cent silica glass No. 7900. This type of glass is also made with high transmission in the ultraviolet region as seen in Fig. 2 which shows the ultraviolet transmission characteristics for 96 per cent silica glass No. 7910. This ultraviolet transmitting glass is used as the envelope for both germicidal and sunlamps, the value of which depends on the generation of ultraviolet light. Moreover, even after five thousand hours' use the mercury arc germicidal lamp in a No. 7910 envelope has an energy output of 73 per cent of the initial value so that solarization loss is much less than in the case of other ultraviolet transmitting glasses.

For this application and others where the glass might be used as an envelope for a lighting source, it is obviously necessary to have a means of sealing in lead wires. This problem has been solved by the

TABLE I.—Physical Properties of Vycor Brand Glasses.

Property	Vycor Brand Glass No. 7900	Pyrex Brand Glass No. 7740	Fused SiO_2
Density (gm.cc.)	2.18	2.23	2.20
Linear expansion coeff. (per °C × 10^7)	7.5	33	5.5
Softening point (°C)	1500	819	1650
Annealing point (°C)	900	553	1150
Electrical resistivity (ohms/cm³)			
Log R at 250°C	9.7	9.1	12^{9}
Log R at 350°C	9.1	6.7	9.7^{9}
Dielectric constant (20°C)	3.8	4.7	3.8
Refractive Index (n_D)	1.458	1.474	1.458

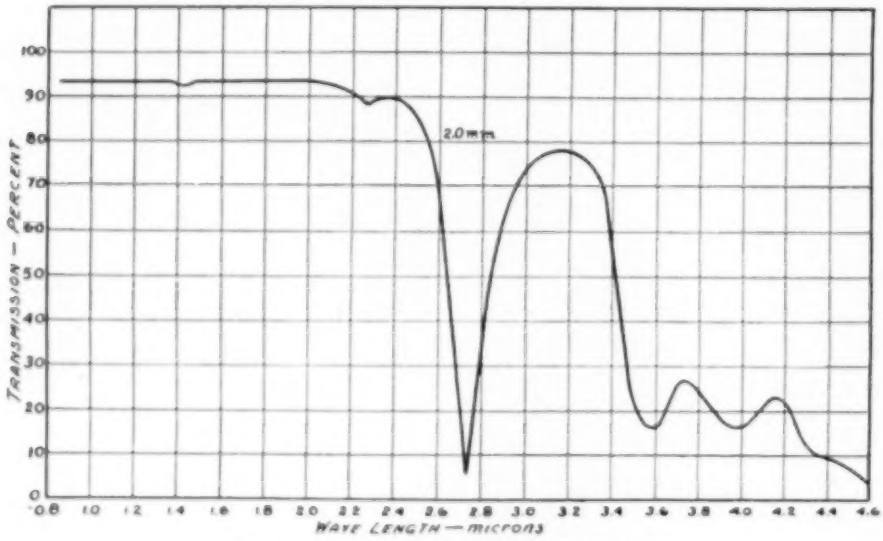


Figure 1. Infrared transmission for Glass No. 7900

development of low cost graded seals which are now available for bridging the gap between 96 per cent silica glass and sealing glasses for tungsten or other metal alloys such as Kovar. The graded seals are made in the form of continuous grades between the hard glass and the metal sealing glass in sizes up to $1\frac{3}{4}$ inches in diameter. Special burners for working 96 per cent silica glass have also been developed for a high speed sealing of these very hard glasses using oxy-hydrogen flames. With such burners, it is now possible to make a seal between a $1\frac{3}{4}$-inch tube of No. 7900 glass and a graded seal in approximately 15 seconds.

Ninety-six per cent silica glass products have a thickness limitation owing to the fact that the time in the leaching process increases rapidly with increasing thickness of glass. At the present time the finished glass thickness limit in general is about 10 millimeters for a clear glass product. Where light transmission is not important, massive ware of thicknesses up to two inches can be made by the Multiform process using 96 per cent silica glass. This process consists essentially of grinding the glass to a powder and forming it by methods similar to ceramic practices with necessary modifications, following by firing. The Multiform product is translucent or opaque white but the other properties are approximately the same as in the original 96 per cent silica glass.

These new Vycor brand 96 per cent silica glasses open up interesting possibilities in the field of illumination. Since the glass has such a high softness temperature and can be used up to 900°C, it is possible to design high wattage lamps with much smaller envelopes than have been previously used. For example, 1250-watt heat lamps with a metallic gold mirror on the inside surface of the bulb have been made experimentally in a shallow envelope only $5\frac{1}{2}$ inches in diameter and some two inches deep. These may be used under extreme conditions with the glass face of the lamp operating at temperatures well above red heat while water may be spilled on the lamp face without breakage.

Cover glasses and lenses can be designed and made in 96 per cent silica glasses for use with extremely high wattage light sources where temperatures are such as to prohibit the use of the well-known heat resisting glasses. In combination with such lenses the new high wattage arc lamps[4, 5] with an extreme concentration of energy in a small source area offer distinct advantages for controlled high intensity beams.

Photosensitive Glasses

The second type of glass which is finding application in the lighting field is the new photosensitive glass[6, 7, 8] in which patterns or pictures can be made right in the glass itself by a photographic process giving minute detail and various color tints. The term photosensitive glass is applied to

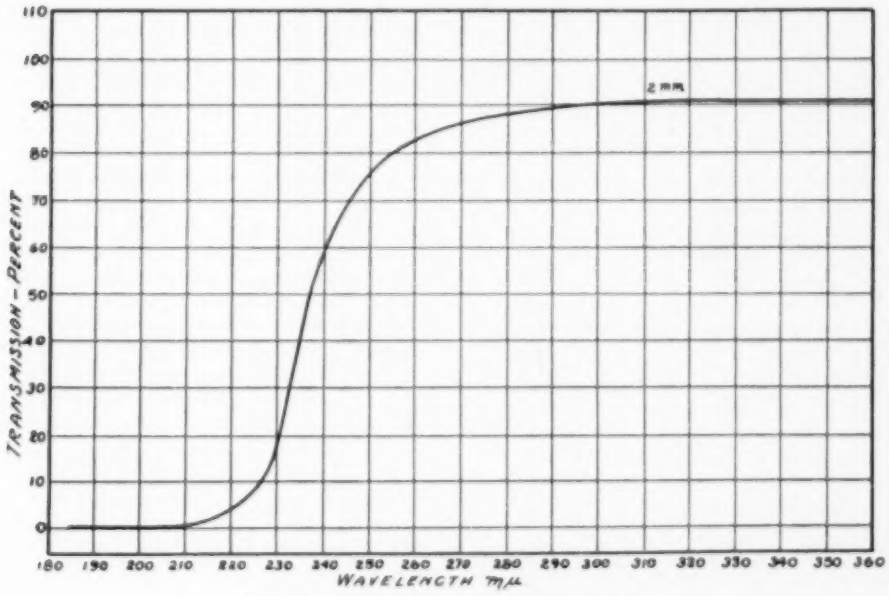


Figure 2. Ultraviolet transmission Glass No. 7910.

glasses which contain in their compositions certain ingredients making them responsive to exposure to ultraviolet light followed by a heat treatment. The essential ingredient in the compositions comprises gold, silver or copper of which gold and silver have proved to be the most useful, preferably together with one or more sensitizers. There are two general varieties of photosensitive glass, one a clear transparency with the picture in various color tints, and the other a clear glass with an opal pattern in white or colors but with the opal either translucent or opaque. Of these two varieties the former lends itself to transparencies with life-like resemblances to the original giving the illusion of a three dimensional effect, while the latter can be developed with an opal pattern through the body of the glass in the form of vanes or louvers which are useful in control of illumination.

Photosensitive glasses are clear high quality glasses melted and manufactured by conventional glass-making methods. They may be formed in any desired shape consistent with the glass manufacturing practice by drawing, rolling, blowing or pressing and may be reworked in a flame prior to the photographic processes without damaging effect. The undeveloped glass can be handled and stored as any conventional glass with the single provision that it should not be exposed to ultraviolet light or sunlight. Such protection can be had merely by shielding the stored glass with a tarpaulin or other opaque cover.

In developing a pattern or picture in a photosensitive glass medium, the process is similar to that used with photographic film or printing paper. It consists of two parts, exposure and development. Ultraviolet light is used for exposure with energy in the wavelength region from 300 to 350 millimicrons. The usual development for photographic film or paper consisting of a chemical developer followed by a fixing bath is replaced by a heat treatment in the case of photosensitive glass which includes heating the glass to a temperature somewhat above red heat for a period of from 5 to 60 minutes and then cooling slowly so as to anneal.

The exposure procedure is quite similar to conventional photographic printing. The negative of the picture or pattern is held in close contact with the photosensitive glass plate and exposed to the light of a carbon arc or other ultraviolet source. Since the image in the glass will penetrate to an appreciable depth or all the way through as desired, it is necessary to use either parallel light or light from a small source at some distance from the plate. Using a 300-watt arc with type *C* cored carbons made by the National Carbon Company the time required for exposure is about 9 minutes for an average negative on Anseo Commercial Ortho film with a spacing of some 12 inches between the light source and the negative. The appearance of the photosensitive glass plate is unchanged by exposure to ultraviolet light so that the latent image is entirely invisible and is only developed by the heat treatment as previously described.

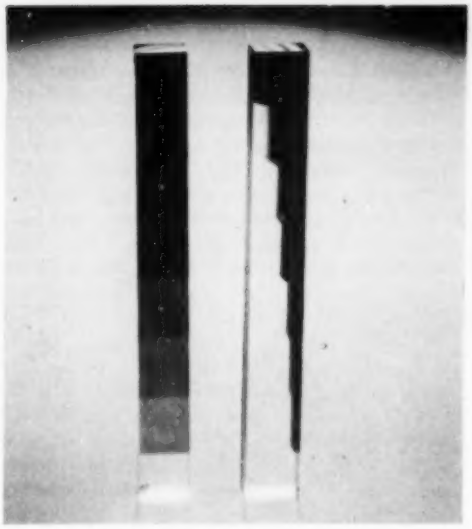


Figure 3.

The pattern or picture is actually in the glass rather than on the surface. This is brought out in Fig. 3 which shows a photograph of two photosensitive glass bars with sections which have been exposed to ultraviolet light for various times and then developed by heat treatment. The front view at the left of the photograph shows the effect of the progressively longer exposure on the overall density of the color. The side view of the bar on the right shows the effect of the progressively longer exposures on the depth of penetration of color. With the longest exposure on the top section the color has penetrated the entire thickness of the glass bar. This penetration produces a sculptured effect in the case of a transparency which creates the appearance of a three dimension particularly if the negative is one having good perspective. If the negative is rather contrasty and the proper glass composition, exposure, and development chosen, various color tints can be obtained in the same picture ranging from blue to red. Other color variations can be had by a choice of glass composition and development conditions from gray and blue to lavender.

No grain effects can be observed in photosensitive

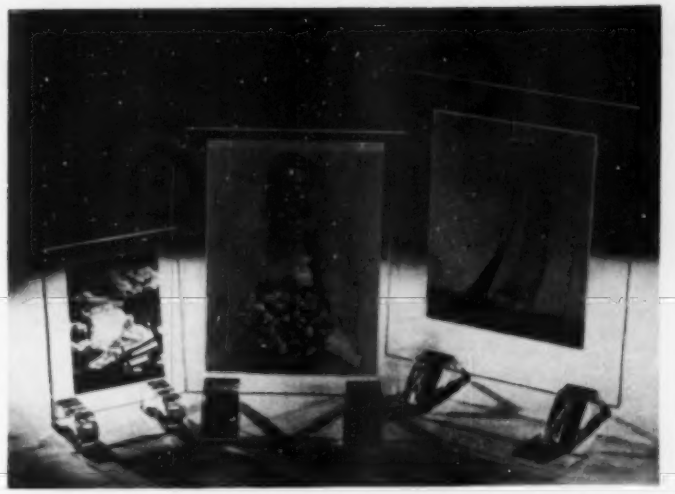


Figure 4.

glass regardless of the degree of magnification. Hence, the pictures show a fineness of detail that is limited only by the grain effects of the original negative. Moreover, photosensitive glass pictures are as permanent as the glass itself with no tendency to fade or darken. They are therefore particularly suited for permanent exhibits or records in the form of microslides. Some examples of finished pictures are shown in Fig. 4.

The photosensitive glass which produces an opal on exposure and development lends itself to many applications in the lighting field. Various patterns with opal louvers or vanes can be developed in this glass in the form of rolled sheet or polished plate as indicated in Figs. 5 and 6. In Fig. 6 two louvered sheets are shown, one normal and the other at an angle of 45° to the observer's line of sight, the latter showing the cut-off obtained with the egg-crate type of louvers. On account of the refraction effects the maximum angular deviation of the vane from the normal is 30° but this limit is sufficiently broad for practical applications. Flat sheets one-eighth inch thick developed with a louvered pattern such as the egg-crate design having approximately one-eighth inch spacing may be used with various types of light sources particularly fluorescent lamps, to control the distribution of light with a cut-off at an angle of 45°. Thus a single sheet of photosensitive glass with the egg-crate louvered pattern can provide the equivalent of mechanical louvers in light control combined with excellent appearance and an ease of maintenance which are very desirable. The fact that the louvers themselves are in the form of white translucent or opaque opal bands with high reflectance and low absorption characteristics results in an efficiency in combination with a good reflector of 70 per cent or above. This new glass is available under the trade name "Fota-Lite" with all the desirable characteristics of permanence, resistance to weathering and ease of cleaning associated with a glass product.

Other types of patterns in Fota-Lite sheet glass can be made such as parallel vanes at desired angles for use in special applications such as show case lighting, and lighting of stove tops and work surfaces where the vanes prevent direct light entering the eye of the worker or observer while at the same time the light is directed over the surface to be illuminated. Tests are also under way to determine the effect of this type of glass in office windows where the louvers are made at an angle to control the direct sunlight striking the window. Such an application may be particularly useful in combination with air conditioning systems since the reflection of the infrared heat rays of the sunlight amounts to as much as 60 per cent with louvers at an angle of 30° to the horizontal and the sun at an elevation of 45°.

Pleasing patterns can be developed with unusual artistic effects for lighting bowls or other types of lighting accessories. Other modifications are possible by combining colored enamel decorations with the photosensitive opals. Such combinations can be made to give sculptured effects in unusual and attractive designs.

Both types of photosensitive glass are available at the present time in the form of flat sheets. Photographic reproductions in photosensitive glass can be obtained from licensed processors who are equipped to produce finished pictures complete with

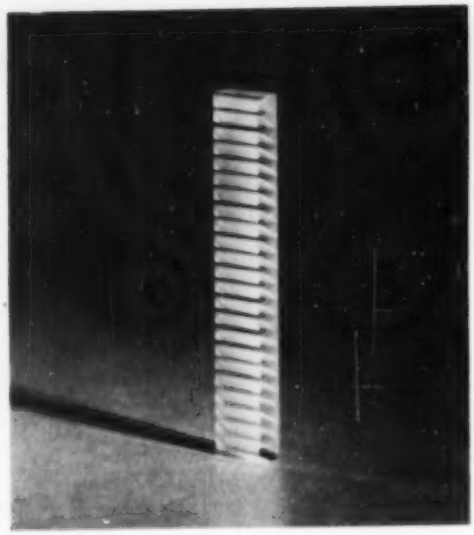


Figure 5.

mountings in sizes up to 10 by 12 inches. Larger sizes up to 40 x 50 inches are also available at the present time. Foto-Lite glass for lighting applications is available through the manufacturers of lighting fixtures.

Summary

In conclusion, the characteristics of these new glasses may be summarized as follows:

(1) Vycor brand 96 per cent silica glasses with properties approaching those of fused silica having low expansion coefficient and high softening temperature can be used to make high wattage incandescent lamps in small envelopes. The necessary graded seals for bringing in the lead wires are available in diameters up to 1¾ inches. Ninety-six per cent silica ultraviolet transmitting glass has materially increased the efficiency of germicidal lamps.

(2) Photosensitive glass of the transparent type constitutes a new medium for photographic reproductions, showing no grain under magnification and having an unlimited life without fading or darkening. Another variety of photosensitive glass permits the development of opal vanes or louvers in the body of flat sheet or other shapes thus providing a means of lighting control having a pleasing appearance, excellent chemical durability, high efficiency and ease of cleaning.

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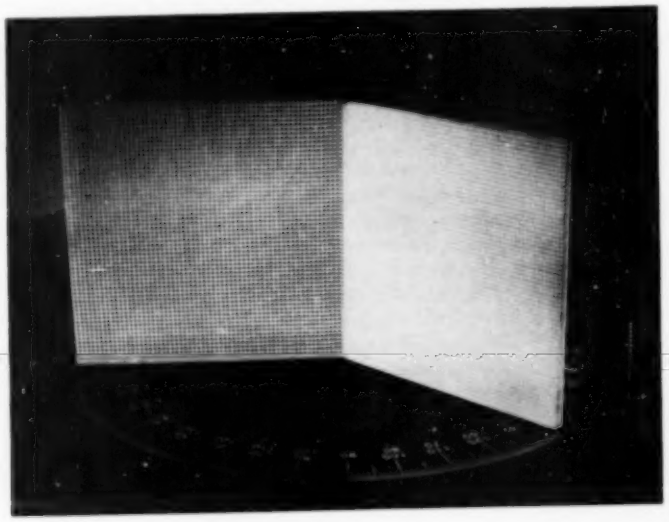

Figure 6.

Wall Lighting

The use of fabrics, murals, and patterned papers on one or more walls of a room suggests the use of light for emphasis of their texture, detail, pattern, or color. Besides this sheer decorative goal, the use of walls to reflect light into a room is a practical way of creating more luminous surroundings. For visual comfort, this is a condition of increasing importance when levels of 20, 40 or more footcandles are delivered at individual furniture groupings. Properly installed wall lighting can provide acceptable illumination, at least for casual eye use, at seating positions close to the wall. It is often used for balancing some specific lighting element on an opposite wall, such as window lighting. It has basic functional application in addition to creating atmospheric and decorative effect.

In general, fluorescent tubes serve best for wall lighting applications. Wall colors and the color of fluorescent tubes used should be coordinated, the choice depending on whether a "cool" or a "warm" atmosphere is desired. Some designers prefer lumilines in early period rooms. They produce a more yellowish-white light approaching the atmosphere associated with candle-light. In modern rooms of extreme functional character, walls may be lighted by bullet-shaped units which use incandescent bulbs of spot or flood distribution. These may be recessed in the ceiling or attached to it, and spaced to provide even or uneven distribution as desired.

There are two general classifications of wall lighting methods: one that illuminates the wall only, and the other which in addition gives some upward light on the ceiling. The former is especially useful for interiors in which the designer prefers to use dark ceilings or to create the effect of a lower ceiling; this may be accomplished by ceiling-recessed or ceiling-attached linear elements or by the use of a wall-length cornice. A cornice is attached to the ceiling, extends down from it and out from the wall. Since the cornice must, for acceptable appearance, be placed relatively closer to the wall than ceiling-recessed units, it does not

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Part II of the Technical Committee Report "Contemporary Lighting in Modern and Traditional Interiors." Approved by Council, June 1950. Part I, September 1950. Part III, next issue.

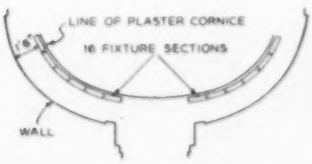


Figure 37. Plan view of ceiling showing the placement of the twelve 16-inch lighting sections.

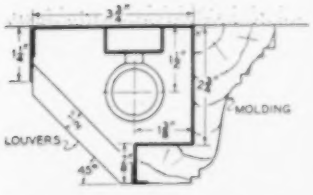


Figure 38. Section through ceiling applied molding and light box. Twin sockets for 25-watt T-12 reflector bulbs are mounted on 16-inch centers.

General Information: A portion of a large oval-shaped entrance hall leading into the library of this Southern Colonial home reveals soft, pleasant lighting reflected from the walls (Fig. 36). The ceiling, 9 feet 10 inches high, is painted a pale beige with the same color in a darker shade repeated on the walls and columns.

Two semi-circular plaster elements of traditional design (Fig. 37) follow the wall contour and are mounted on the ceiling one foot six inches from the walls. Each ceiling element conceals six 16-inch fixture sections, each housing two reflector bulbs (Fig. 38). Vertical louvers spaced one and one-quarter inches apart shield the sources from any normal viewing angle.

The hurricane glass and metal wall brackets equipped with six-volt electric wax candles are an appropriate decorative feature prominently located to give the illusion of providing the glow of light in the entrance.

Figure 36.

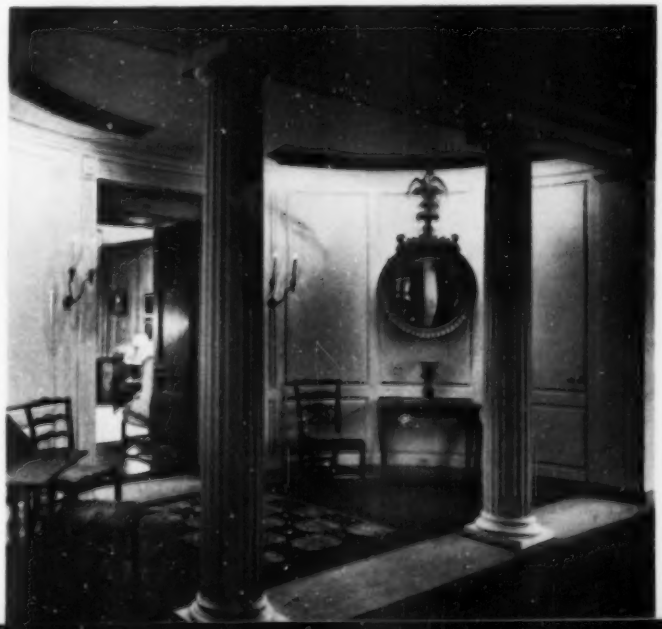


Figure 39.

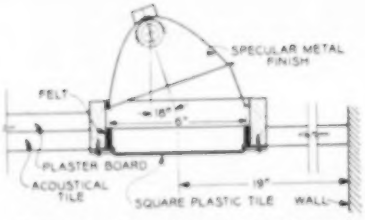


Figure 40. Section through ceiling-recessed wall lighting unit using T-6, 42-inch and 64-inch fluorescent tubes; ballasts in separate box.

General Information: In this installation (Fig. 39), it was the endeavor to create "washes" of light on the walls in a manner similar to the filtering of natural daylight throughout an interior. It was further desired to incorporate the lighting system within the structure, and to maintain the proper scale, harmony, and refinement of a fine domestic interior.

The overall dimensions of the living and dining area are 18 feet x 28 feet with an 8-foot 9-inch ceiling. The ceiling of acoustical material has been hung from the ceiling joists so that recessed boxes could be used along all four sides. Lengthwise of the room are two continuous strips 6 inches x 21 feet with the center 19 inches from the side walls. Crosswise of the room are two similar strips, eight feet long across one end and 11 feet long across the other. The use of three-quarter-inch diameter instant start tubes and specular polished parabolic reflectors (five inches in cross section) provides the desired degree of directional control down the walls. The reflector is tilted for maximum uniformity of wall lighting and for tube shielding (Fig. 40). The plastic tiles covering the apertures are joined together in easily handled strips (for tube replacement) and are very lightly etched to keep their brightness low. The bottom side of the tiles protrudes slightly below the ceiling line to eliminate the otherwise dark area on the upper wall near the ceiling.

This system alone provides from four footcandles in the center of the room to 16 footcandles at the sides. The variation in wall brightness from ceiling to floor is less than 10 to 1 (average about 15 footlamberts). Eight 64-inch and five 42-inch fluorescent tubes operated at 200 ma are used, totaling 616 watts. Ballast wattage is included. The walls are painted a warm tone of grayed yellow-red of approximately 50 per cent reflectance.

To avoid monotony and to introduce ever-desirable highlight and shadow, the important long walls utilize a variety of decorative and additional lighting ideas. On the wall illustrated, the system described is effective in accenting the sculptured mirror frame and the curved silver-finished fireplace treatment.

General Information: One entire wall of the interior shown in Fig. 42 is designed of glass to reveal an unobstructed daytime and nighttime view of the illuminated terrace-garden. When greater privacy is desired, curtains can be drawn across the upper and lower glass sections.

The room is 19 feet x 25 feet with a pitched beam ceiling that graduates from eight feet to twelve and one-half feet in height, with the beams three feet apart. The fireplace wall is of earthy-pink stone; the other wall areas are a rose-beige, the ceiling is a peach-beige, the curtains and rug are beige and the floor is reddish brown.

Two large-scale semi-indirect table lamps and three downlights, primarily for decorative effect, provide local and general illumination at the furniture groups opposite the terrace wall. To create a balanced lighting effect on the terrace window-wall and to reproduce substantially the daylight "feeling" of luminous curtains, strips of lighting and curtain fabric combine to reflect a pleasant glow into the room. Boxes 33 inches long are mounted on the ceiling between the beams and painted the same color as the ceiling. Each box contains five inside-frosted incandescent bulbs each centered above a concentrating lens (Fig. 41). A hinged bronze louver screen is attached beneath each box to reduce lens brightness. The downlights and the window-wall lighting are controlled by a dimmer, allowing flexibility in lighting levels to serve the varied informal activities in this room. When the outdoor scene becomes the center of interest, the wall lighting can be reduced to a minimum level by use of the dimmer.

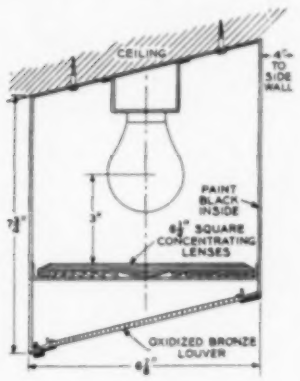


Figure 41. Section through ceiling attached box. Each box contains five 60-watt inside-frosted bulbs on 6½-inch centers above individual concentrating lenses.

The range of brightness readings on the curtains is: upper curtains from 0.5 to 5.0 footlamberts, lower curtains from 0.4 to 2.5 footlamberts. Footcandle readings on the table top average eight; in the immediate vicinity of the window-wall (18 inches from the wall on a 30-inch plane) the footcandles average approximately 20.

Figure 42.

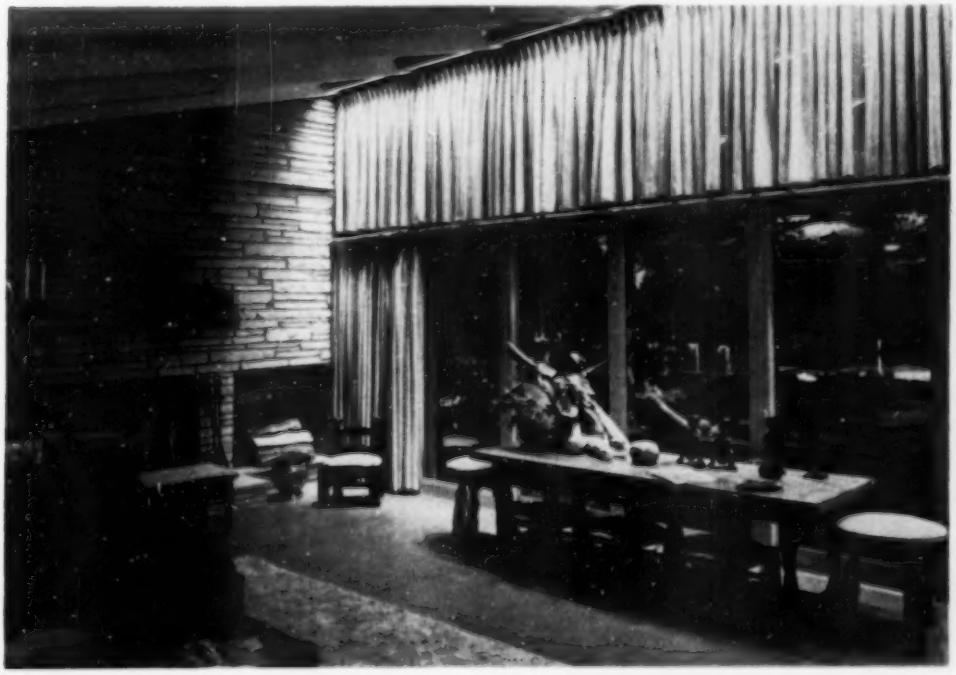


Figure 43.

General Information: In this basement recreation room (Fig. 43) the requirement was to light one landscape-painted wall to attain the illusion of a distant view and thus to take the room "out of the basement."

The wall is 14 feet wide and eight feet high. Wiring channel is mounted on the ceiling 12 inches out from the wall, with standard medium sockets on 12-inch centers. Twenty-five watt and 40-watt incandescent bulbs are used alternately thus avoiding too uniform illumination on the scene. The yellowish white light provided creates a late afternoon atmosphere. The awning gives the illusion of sitting "out on the porch." Cool white fluorescent tubes would change the effect to cool summer skylight.

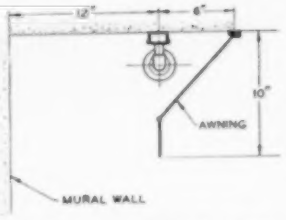


Figure 44. Section through ceiling-attached wiring channel and shielding awning. Sockets on 12-inch centers use alternate 25-watt and 40-watt bulbs.

Continued from page 637

supply quite as even illumination from the top to the bottom of the wall. This is not necessarily a weakness since a plain wall evenly lighted is often uninteresting. If the wall treatment itself does not offer variation in pattern or reflection, the light provides a means of introducing it.

The cornice should be at least six inches out from the wall. As this distance is increased, the brightness of the wall from ceiling to floor becomes more nearly uniform. The wiring channel and tubes should be mounted on the ceiling as close as possible to the cornice. More than one row is often practicable to thus allow variety of light level or color. The vertical depth of the cornice from top to bottom must be at least six inches for normal shielding in rooms of average height. This depth would provide ample shielding only if one row of small wiring channel were used (not including ballasts). When the ballast is included in the channel or when two rows are used, the cornice must be at least eight inches deep. In rooms with higher ceilings, greater vertical depth will be necessary for adequate shielding or shielding louvers may be introduced as in Fig. 45. Vertical depth is also always influenced by decorative proportion.

When lighting on the ceiling is desirable in combination with wall-lighting, the fluorescent wall-bracket offers an entirely new medium. Because of the variety of fluorescent tube lengths, wall-brackets may be made in any length and tailored to fit almost any application. Because they provide high light output and a good distribution of lighting within their area, they are the solution to many awkward lighting problems. On inner walls they serve to balance valance lighting from the window walls, and they also provide excellent general lighting in rooms with low ceilings. A minimum of 10 inches between the ceiling and the top edge of the bracket is desirable. The bottom edge may be as low as 68 inches above the floor, or even lower when the bracket is designed to provide functional illumination at specific wall-placed furniture such as beds and davenports. Shielding on the upper side of the bracket is then often essen-

General Information: The beauty and simplicity of contemporary design is reflected in the decor of this foyer (Fig. 46) which is 7 feet 9 inches x 18 feet 3 inches with a 9-foot 6-inch ceiling. One long wall above the dado is treated in a silver and flame paper of Chinese design; the other wall areas and the wood trim are painted café-au-lait and the draperies are of the same color. The furniture is of blond mahogany, the rug a light beige. The ceiling is white, and the chairs are covered in a fabric which matches the flame color of the paper.

To accomplish the lighting atmosphere desired, a wood cornice, café-au-lait in color, extends across the papered wall concealing two rows of 30-watt fluorescent tubes placed end-to-end (Fig. 45). Each row contains six tubes, and the rows are staggered to prevent shadows from the sockets and to get wall-to-wall coverage. Ballasts are remotely installed. Louvers, baffles, or shields are recommended for installations of this type when the light sources are visible from any normal seated or standing position. Here louvers on 4-inch centers are attached to the cornice leaving sufficient space at the wall side for relamping.

To balance and complement the wall lighting, a 40-watt fluorescent tube is concealed behind each satin-tufted window valance on the opposite wall. These valances are closed at the top to produce direct light to match the cornice light. Ballasts are installed in the wiring channel.

This method of wall and window illumination creates an effective and inviting atmosphere. It accents the colorful wallpaper and the beauty of all the furnishings and decorative accessories. In a foyer the shiny wallpaper is acceptable because people are in the room for such short intervals. In other rooms its use would be discouraged.

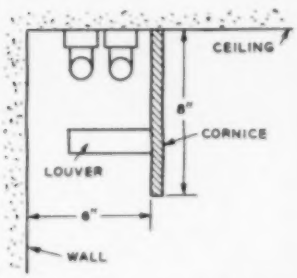


Figure 45. Section through cornice and staggered rows of T-8 30-watt fluorescent tubes; ballasts in separate box. Louvers are on four inch centers.

tinl. As in the case of window valances, the wiring channel for a wall bracket is mounted on a wood block of a thickness to position the tube center at least four inches from the wall. It is important that the wiring channel and the inner surface of the bracket be painted white. The bracket may be opaque, or of translucent glass or plastic.

Wall finish should be non-glossy and of medium reflectance, generally between 35 and 55 per cent. Higher reflectance often creates excessive wall brightness, especially when large areas are involved. Lower reflectances defeat the stated purposes of wall lighting, although the addition of light even to dark walls increases their colorfulness.

Figure 46.

General Information: Close inspection of the detail drawing (Fig. 48) of this wall lighting installation (Fig. 47) will show that while it appears to be similar to the cornice designs previously illustrated it is actually a bottom-shielded cornice which prevents viewing the tubes from any viewing position in the hall.

This is an entrance hall 14 feet x 10 feet with a seven and one-half foot ceiling. The scenic paper which covers one entire wall shades from full white through the grays to black; the woodwork and brick dado are white; and the ceiling and cornice are a light gray.

Three fluorescent tubes illuminate the mural wall. The light reflected from the wall is supplemented by a ceiling fixture. It is a bird cage, wired to accommodate three 25-watt bulbs. The bulbs are shielded by inserts of plastic in the bottom and lower side sections

Figure 47.

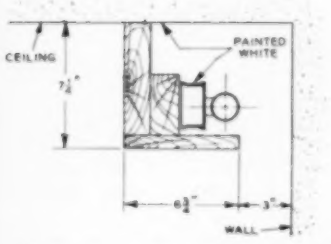


Figure 48. Section through bottom shielded cornice with T-12, 40-watt tubes; ballasts in channel.

Figure 49.

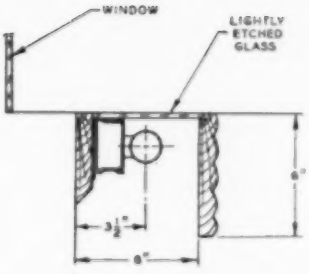


Figure 50. Section through wall bracket, mounted at the lower edges of the windows. The T-12, 40-watt tubes are used with ballasts in the channel.

General Information: In this basement recreation room (Fig. 49) the bar was an addition made some time after the completion of the house. The problem then was to introduce appropriately useful and decorative lighting.

The width of the room is 12 feet 6 inches and the ceiling height is 7 feet 6 inches. Above the knotty pine dado the walls and ceiling are cream colored plaster. The small, high windows are curtained in bright red chintz.

A wall-to-wall fluorescent bracket (Fig. 50), mounted in line with the lower edge of the windows is a practical solution here. An etched glass plate is inset in the top both to create a shelf and to permit upward light accent on accessories placed there.

The lighting effect achieved proved highly satisfactory. The principle involved is suggestive of a simple method of handling the general lighting in many recreation rooms of this typical construction.

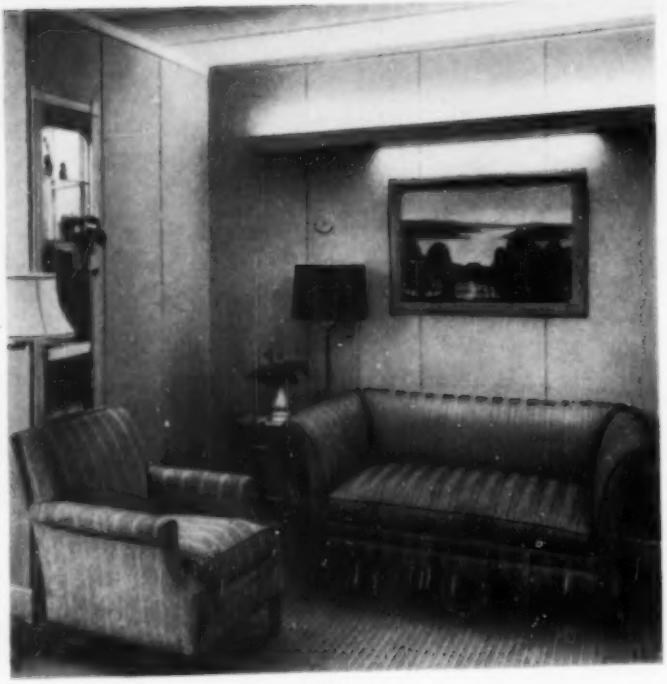


Figure 51.

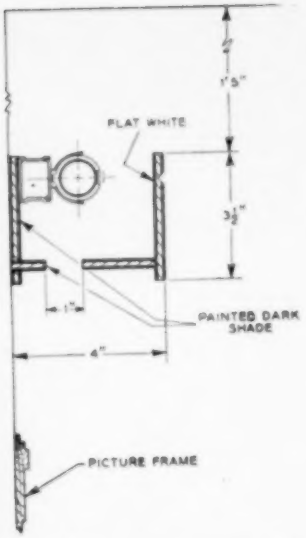


Figure 52. Section through ¼-inch plywood wall bracket; ballast in separate box. The close spacing is made possible by the use of narrow channel, clip-held lamp holders, and the low current operation of T-6 tubes.

General Information: In this residential office (Fig. 51) a 12-foot lighted window-valance was used on the window wall, and a similar lighting distribution was desired on the adjoining walls to create a balanced effect throughout the room. Lighted wall brackets were the natural answer. A bracket of the same dimension as the window valance, scaled for a large window, would have been too bulky for decorative acceptance.

It is not feasible with the standard fluorescent tubes to reduce materially the dimensions detailed in Fig. 50 without increasing to disturbing levels the brightness of the adjacent wall. The smaller-diameter instant start tubes can be operated at a low current producing less light. Thus they may be placed nearer to the wall without excessive wall brightness. By locating the ballast elsewhere, the smallest one-inch wiring channel may be used, reducing the bracket dimension as shown in Fig. 52. This dimension would have to be increased if other than three-quarter inch diameter tubes were used. In this installation two 42-inch tubes are employed.

Because of the small vertical depth of the bracket, the inner surface would be visible and uncomfortably bright from normal viewing positions if the bottom were not partially closed. It may have a narrow opening located as shown in Fig. 52, either full-length for downlighting or the correct length to highlight a picture as shown here. The picture must be hung tight to the wall and have a flat frame. If a slot is used, the back inner face of the bracket and of the slot opening should be painted a dark shade of the bracket color, or a dark gray, to avoid unpleasant high brightness when the bracket is lighted.

The delicate scaling of the bracket does not lessen its lighting effectiveness, and greatly broadens the possible applications of this lighting treatment.

General Information: This master bedroom (Fig. 53) is small — 11 feet x 12 feet. It is typical of modern house planning, even to the absence of any permanently installed lighting. With minimum basic furniture: twin beds, bureau, bedside table and slipper chair, the room requires careful handling to avoid cramped living.

Satisfactory lighting for reading in bed, for makeup, and for dressing is solved here in a space-saving manner. A seven-foot fluorescent bracket is mounted on the bed wall, centered above the beds. Its wallpaper treatment, its unusual vertical depth, and its bold but curved lower edge keep it in harmony with the wall treatment and in scale with the Hollywood beds. It establishes dramatically a new form of bed head which is both decorative and functional. Two fluorescent tubes provide a satisfactory reading level and cheerful room lighting (see Fig. 54).

Opposite the bed wall are two corner windows treated as one with a continuous right-angle valance of the same design as the wall bracket. It uses two 30-watt fluorescent tubes. Certified dresser lamps complete the room's lighting with seemingly spacious livability.

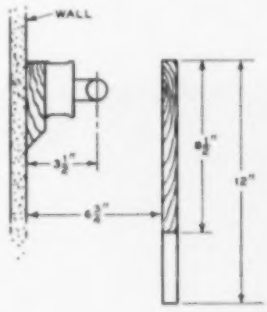


Figure 54. Cross-section of over bed bracket, ballast in channel, 30-watt, T-8 tubes are used. The depth of the shield varies between 8½ inches and 12 inches, with the lower edge 28 inches above the mattress top.

Figure 53.

General Information: This 15-foot long hallway (Fig. 55) connects the entrance foyer with the living room. Useful illumination for safe seeing is attained without undue interference with the nighttime view through the window-wall.

Incorporated in the long window sill are five fluorescent tubes in reflectors (Fig. 56). A wooden apron approximately two inches deep conceals the lighting equipment. The ballasts are located in the basement.

A pleasing glow of light is reflected from the light beige-colored wall below the windows. Without competing with or erasing the view, an average of 10 to 15 footcandles is delivered on the floor.

← *Figure 55.*

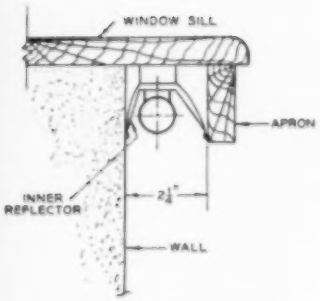


Figure 56. Section through window-sill strip using T-8, 30-watt tubes, ballasts in separate box.

Lighting From Ceiling Fixtures and Wall Brackets

Contemporary lighting practice includes the use of ceiling- and wall-mounted luminaires, more conventionally referred to as ceiling fixtures and wall brackets. Prior to World War I, American homes were equipped with fixtures of beautiful metals and glass, some of which, however, were not very efficient from the standpoint of today's illumination requirements. Following World War I many unsightly bare bulb designs were installed. The latter were removed in redecorating and omitted in new buildings. The trend of eliminating fixtures other than those in the strictly utility rooms continues. However, today there is no lack of attractive and appropriate fixture designs for either the Traditional or the Contemporary interior. The rooms illustrated in this section, as well as a few elsewhere in this publication, show the acceptance and use of a variety of fixtures in other than the utilitarian rooms of a home.

For those who prefer candle-style chandeliers there are types in crystal, brass, silver, tole, bronze, pewter and others with decorative motifs of period design for Traditional interiors. When miniature clear bulbs are used, other forms of lighting should be included in the interior to provide visual comfort. Appropriate individual candle shades over standard incandescent bulbs are required. Designers are constantly striving to produce a greater quantity of light, and lighting that is less glaring, from these accepted Traditional fixtures. For example, today there are some magnificent domestic and imported crystal chandeliers that retain all the charm and grace of Traditional elegance. This is accomplished by concealing bulbs within the fixture body or its bobeches to provide lighting in keeping with Contemporary living.

Between the strictly period fixtures and those of unmistakably modern design, there are styles that incorporate some of the features of the past as well as those that have a modern "feeling." There is a wide selection of designs that if well chosen will add to, and not detract from, the beauty and charm of a carefully decorated interior.

The Purpose of Ceiling and Wall Fixtures

It is a measure of convenience and safety to be able to switch on lighting throughout a room, in a hall, or on the stairway. Ceiling fixtures are the most obvious and usually the least costly way of providing general illumination, and this is their primary purpose. A ceiling luminaire adds to the flexibility of a room's lighting scheme and also provides an additional source of illumination in the center of a room for activities in that area. However, the symmetrical distribution of light from most ceiling fixtures offers less interest and variation in emphasis than the built-in or applied methods previously discussed.

Some attractive candle-type wall brackets are installed in Traditional interiors for secondary or background lighting effect. Wall brackets designed to produce semi-indirect or indirect illumination, if used in sufficient numbers and located to distribute light throughout a room, may be used alone or in conjunction with a ceiling luminaire as a means of providing general illumination in halls, dining areas, recreation rooms, and living rooms.

Selection of Fixtures and Brackets

Five major factors should be considered in selecting fixtures and brackets:

1. Lighting qualities: light distribution, brightness, wattage, and efficiency
2. Aesthetic design factors: scale and proportion in relation to room dimensions
3. Appropriateness of decorative style: suitability of material, finish and motif
4. Electrical and mechanical construction
5. Maintenance features: ease of cleaning and relamping

The relative values of these factors vary with the requirements for the individual application. Pages could be written to aid in the proper selection of fixtures and wall brackets, but it must suffice here to list a few important advances made in fixture design:

New fixtures of creditable and varied styling use large area (16 to 24 inches round or square) shallow glass, and hang closer to the ceiling. Being in more appropriate scale with their ceiling surround, they are less conspicuous and become more frankly a lighting element than an afterthought appendage.

The increased area allows a desirable increase in numbers of sockets resulting in higher light output but with conspicuously lower brightness. This type of fixture contributes more flattering and useful illumination than its smaller predecessor.

New fixtures also exhibit great advances in simplicity of design detail and luminous qualities of the glassware used.

A variety of new designs, especially for dining areas, incorporate more than one light distribution to provide both dramatic downlighting over a limited area and general room lighting.

In general, the following types should be avoided:

Those utilizing strong color in the major portion of the glassware or plastic.

Exposed bulb types.

Those using etched and crystal glass in combination with incandescent bulbs (these are excessively bright).

Fixtures smaller than 12 inches across, except in very small areas such as vestibules and passageways.

Open top, low hanging types near stairways.

Single, small recessed units in the center of the ceiling, without other methods of indirect lighting.

The examples shown in Fig. 57 represent some of the desirable present-day designs of ceiling fixtures and wall brackets.

FIG. 57A. Current designs of ceiling fixtures

FIG. 57B. Wall and ceiling fixtures

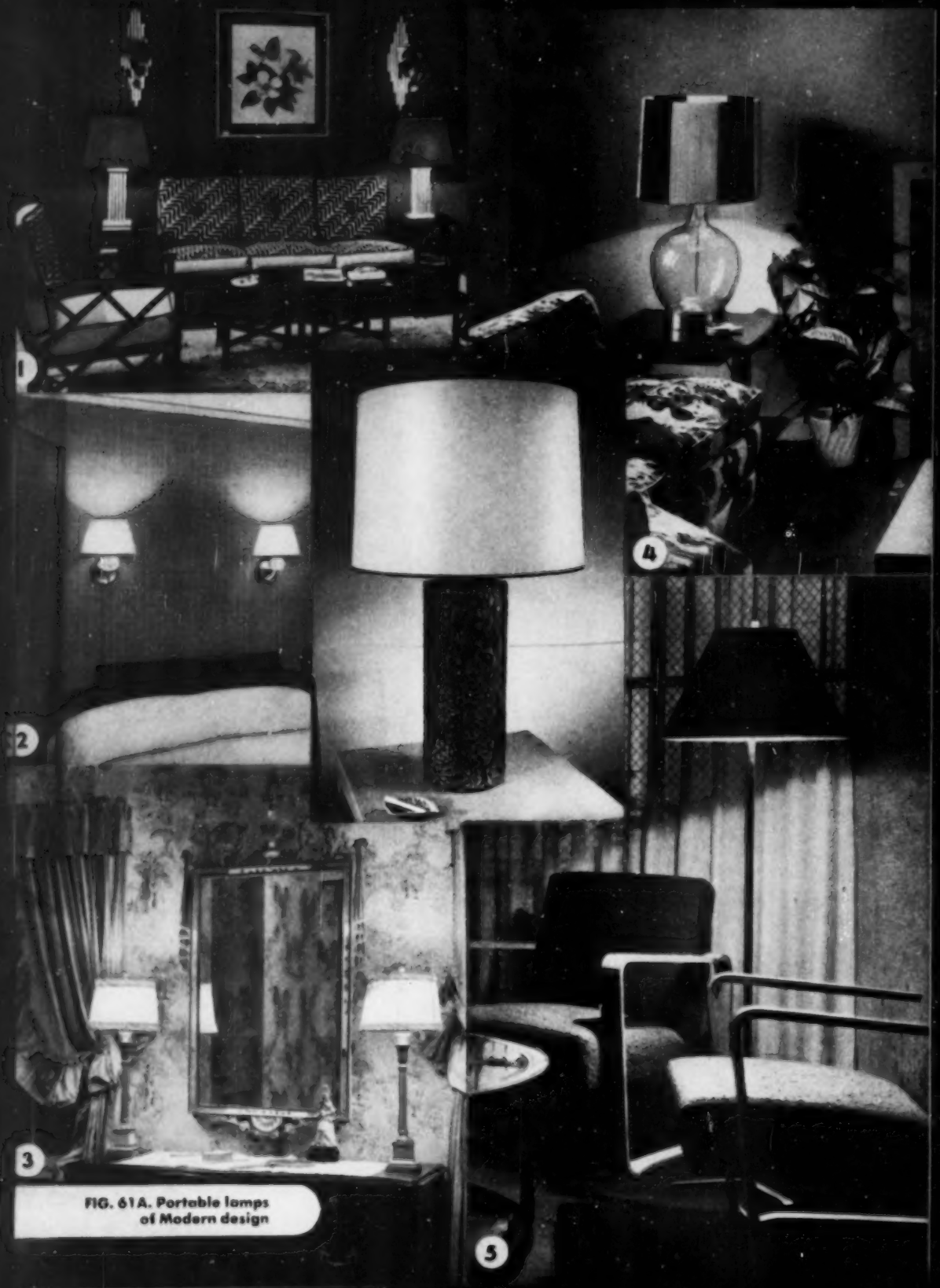


FIG. 61A. Portable lamps of Modern design

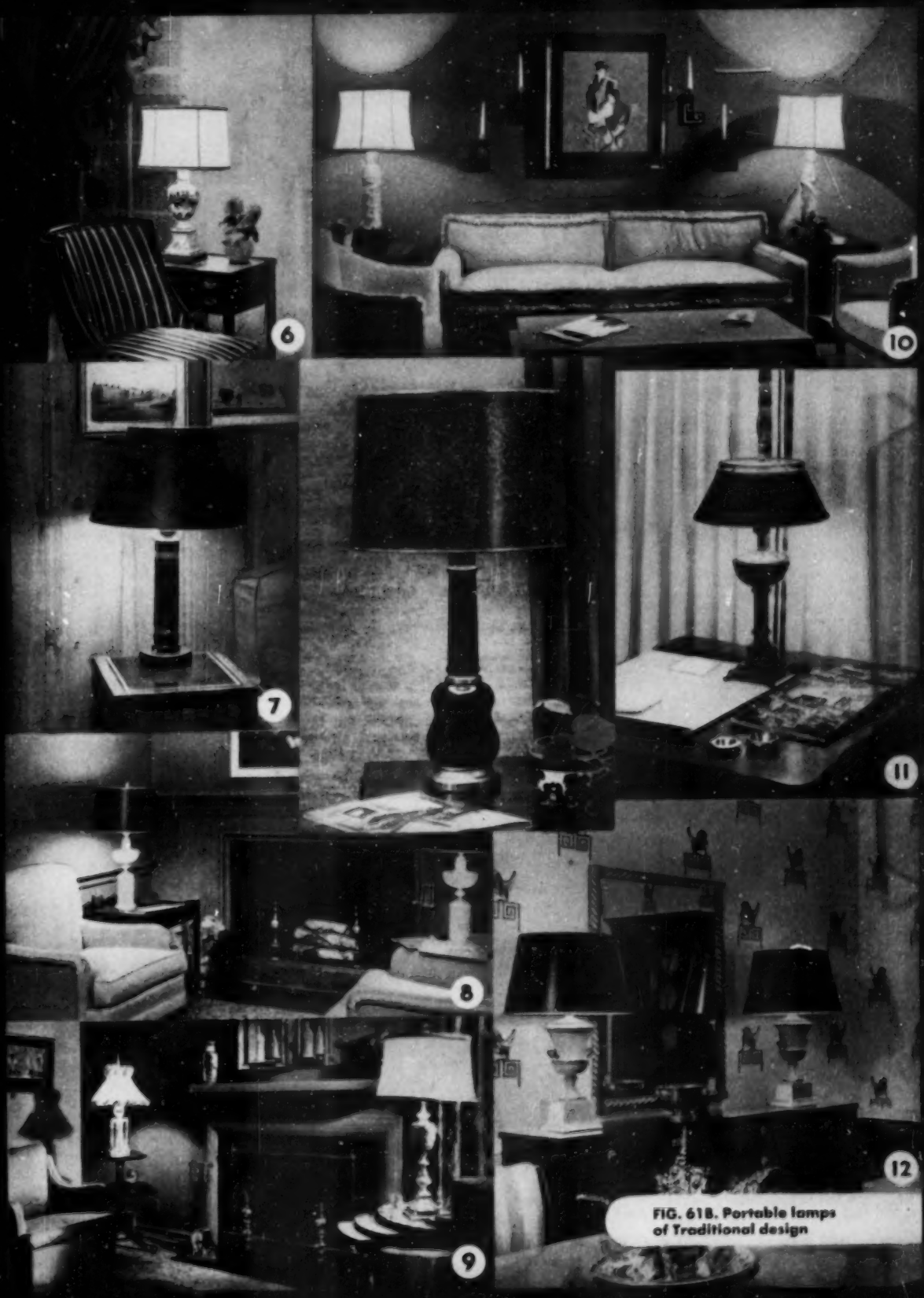


FIG. 618. Portable lamps of Traditional design

Lighting From Portable Lamps

There is history, beauty, and romance in "portable" lamps. They contribute character and interest to an interior and afford sentimental appeal. The very luminosity of a lamp sets it apart from other objects in a room. It bestows qualities upon its surroundings that no other decorating medium possesses.

The styling talents of hundreds of designers have long been applied to the creation of increasingly beautiful and individual lamps — table, floor, and wall-hung. Endless variety of form, material, decorative motif, and finish permit their harmony with all fine furniture and period styles. Such progress has been made in their styling and decorative qualities that they have become to many the most important accessory in the coordinated scheme of an interior. In a few of the advanced modern interiors as well as in very small rooms, there is a trend to eliminate lamps in favor of completely built-in or structurally applied lighting. For the majority of homes, their charm and mobile usefulness will insure their continued popularity.

Fundamentally, the portable lamp evolved from the need to bring the light close to the user to provide greater facility in seeing. It is clear that the mere presence of a bulb within the portable lamp does not fit it for the combined functional and decorative role it can play. Control and useful distribution of the light through the shade is essential. Then only will the use of a lamp be as visually comfortable as it is attractive. There are some applications in which "eye-use" is not a consideration, but they are in a minority. There is real need for more widespread coordination of the technical "under-the-shade" design of a lamp with the overall artistic design.

Progress in this direction is evidenced by increased use of the inner glass or plastic bowls. The purpose of the bowl is to diffuse the light and to afford relief from distracting reflections on the printed page. There are now in common use diffusing bowls in a variety of sizes, shapes, transmitting and reflecting qualities. Recent developments (Fig. 58) combine a metal crown with a new and carefully engineered glass-bowl shape. They provide somewhat higher amounts of downward light than did earlier bowl types using the same bulb size. In common with many of the earlier bowls, they are designed for three-light bulbs which allow a choice of illumination level. Some models include a circular fluorescent tube for more light and flexibility (Fig. 59). The metal crown serves also to control the brightness seen from standing positions. It holds the shade correctly so that the light may be effectively distributed over a usable area. Portable lamps with this light control undergo rigid tests by an independent testing laboratory. They bear a certification tag which marks their compliance with specifications for good lighting performance, electrical safety, and sound construction.

An incandescent bulb with a special white coating has been developed in 150-watt and 200-watt sizes, designated as R-40, for use without a diffusing bowl (Fig. 60). Its larger area and special coating offer improvement over the harsher light from standard inside-frosted bulbs, but with less refinement in lighting quality* than may be derived from the best diffusing bowls.

Lamp shades should have white or near-white linings. Whether they are opaque or translucent is a matter of taste and decorative suitability. Opaque ones are generally preferable if strong accent color is desired or if they are viewed against dark backgrounds. At study desks, low-brightness translucent shades are best. Shades on dresser or

*The resultant brightnesses do not meet the provisions of the "Lighting Performance Recommendations for Portable and Installed Residence Luminaires" of the Illuminating Engineering Society.

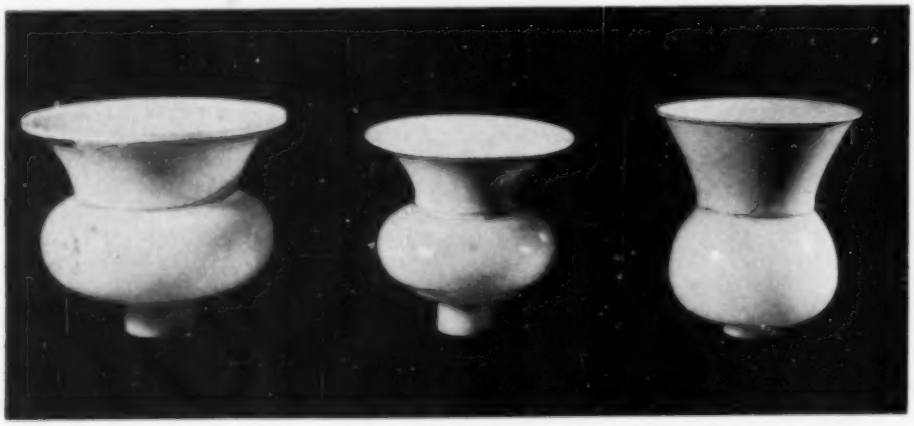


Figure 58. Diffusing glass bowls and metal reflectors (crowns) are combined in these most recent developments for "under-shade" lighting design. The largest size is designed for the 100/300-watt bulb, the others for the 50/150-watt bulb. Each supplies maximum illumination consistent with good styling and good lighting quality.

Figure 59. Floor models which combine the 12-inch circular fluorescent tube with the largest bowl of this newest type provide approximately 50 footcandles when they are placed close beside and slightly to the rear of the user.

←

Figure 60. The size and special white coating of this R 40 bulb allow its use in a wide harp without a diffusing bowl. It supplies light levels equivalent to those from the smaller bowls in Fig. 58 but with less refinement in lighting quality.

→

dressing table lamps should avoid strong color except possibly in the trim. White or the warm-toned translucent pastels provide a truer light for make-up. Under-shade bowls should not be used in dresser or dressing-table lamps. Lamp shades for use on other than strictly decorative lamps should be large enough at top and bottom to permit a wide distribution of light both downward and upward.

The placement of lamps within individual furniture groupings is extremely important if one is to obtain the desired lighting without the annoyance and distraction of sewing into the shade. Choice of table-lamp height should be influenced by seat height and the height of the table. The lower edge of the shade should be approximately at the eye level of the person seated beside it. Then the lamp may be comfortably placed in line with and close to the shoulder. Floor lamps, because the lower edge of the shade is considerably above eye level, need to be placed at one side or the other and some inches to the rear of the shoulder. Left-side placement is important only when the light is used for hand-work by the right-handed, as for sewing or at desks.

Wall lamps of current design find their greatest application for reading in bed. In general, they are more applicable in modest and informal interiors. Wall lamps are popular because of their low cost and ready placement where light is needed but where table or floor space is not available.

Torcheres — in ornamental table or floor forms — cannot be depended upon for "local" lighting within furniture groupings. They have wide application as a portable means of introducing indirect lighting. When properly designed and placed they may prove excellent in rooms in which there is extensive television-viewing.

Some indication of the wide range of portable lamp types, sizes, styling, materials, and application is shown in Fig. 61. Here selections were made with attention to appropriateness both of lighting design and decorative harmony.

TELECAST

LIGHTING NEWS OF CURRENT INTEREST

The I. E. S. Pasadena Conference

The National Technical Conference doesn't go to the west coast often — but when it does, as in 1939 and 1950, I.E.S. history gains another highlight. An intangible filip seems to be added to California meetings — the guests are so far from home; having "company" is not an everyday occasion. At any rate, the 1950 Conference August 21-24 at the Hotel Huntington, Pasadena, California, furnished in all respects 1950's most important I.E.S. meeting.

The early birds started arriving by train, plane and auto on Saturday and Sunday with the registration booth open on Sunday noon. President and Mrs. Goddard arrived Saturday by train and when met by a local welcoming committee complete with a troupe of Spanish musicians in costume, the versatile I.E.S. President turned the tables neatly. Snatching a sombrero and guitar from one of the musicians, he strummed up some "Celito Linda" on his own and carried on quite a conversation in Spanish.

Sunday was a chance for advance planning groups to jell programs, meet old acquaintances and reminisce over "a cold one" at the popular Ship Room of the hotel. The Huntington in Pasadena was an ideal choice for a fine atmosphere for relaxation, enjoyment and leisure. Within driving distance of the large metropolitan area of Los Angeles, and close to visiting points in Southern California, the quiet resort surroundings enabled concentrated attendance at the technical sessions, fun and frolic afterward.

Technical Program

A California vacation, as billed, was an outstanding feature of the Pasadena Conference. However, the scope and importance of the technical program presented there constitutes the most significant event of the year in the lighting field. Starting Monday afternoon, the technical sessions presented 36 interesting papers on a wide variety of subjects ranging from general interest to specifically those on Light Sources, Street Lighting, Residence Lighting and Aviation Lighting. Many of the technical papers found wide interest in the local press and magazines. Outstanding developments in the art were dramatized in the presentation of the report of the Progress Committee; a report to the membership was given by the incumbent President; the year's activities reported by the General Secretary; the Society's path during the next year was outlined by the incoming President. One session of special interest to non-member visitors, was the symposium on Aviation Lighting, held Thursday morning, August 24. A large delegation attended this meeting, attracted by the highly significant aviation studies reported there. Abstracts of the 36 technical papers were published in the September issue of Illuminating Engineering. A limited number of proceedings issues of the Conference papers are available from Headquarters at $2.00 per set. For the record, a list of the entire technical program is given at the end of this report.

Opening Session

The 1950 Conference was officially opened at 11:00 a.m. on Monday, August 21, by R. F. Hartenstein, who as chairman of the National Technical Conference Committee, has guided to success the past three Conferences. The Address of Welcome was given by Mr. Samuel B. Morris, General Manager and Chief Engineer of the Los Angeles Department of Water and Power, who welcomed all delegates, and told of the growth, since 1781, of one of the country's largest water and power developments, and of Los Angeles' fine development and improvement of street lighting. The ever-interesting Report of the General Secretary was presented by A. H. Manwaring, followed by the President's Annual Address by Charles H. Goddard, and the Society's Aims in 1950-1951, by Presi-

I.E.S. MEDALLIST Wm. F. Little (right) receives the Society's highest honor, the I.E.S. Gold Medal, from President Goddard during ceremonies following the opening session.

FELLOW certificates were presented to four newly-elected I.E.S. Fellows following the opening session August 21. Receiving congratulations from President Goddard (left) are J. M. Ketch, Willard Allphin and E. W. Commery.

dent-Elect Sturrock. The addresses of both the outgoing and incoming Presidents have been published in full in the September issue of ILLUMINATING ENGINEERING.

Highlights also of the Opening Session were the presentation of the Society's highest honor — the I.E.S. Gold Medal and Certificate — to W. F. Little, and the presentation of Fellow emblem pins and certificates to four newly-elected Fellows — Willard Allphin and E. F. Lowry of the New England Section, and E. W. Commery and J. M. Ketch of the Cleveland Section. President Goddard also presented a Member Emeritus Certificate to Frank A. Hansen of the Southern California Section, in recognition of his long service to the Society.

PROGRESS REPORT

A special session on Wednesday evening featured the annual Report of the Progress Committee, playing to a full house (S.R.O.). This was a stage presentation highlighting the year's lighting progress, presented by Alston Rodgers, Chairman of the Committee. This presentation traditionally goes far beyond a report of developments. It is, and was again this year, a fascinating show of interest to wives, visitors and the most erudite of delegates. Mr. Rodgers showed by slides or actual demonstration many new and interesting uses of light, new sources and new equipment, such as "Flying Saucer" table lamps, new black light filter glasses and new Christmas tree lamps. Also shown were new bulb shapes and designs, new glass and plastic panels. One of the delights was the manner in which he demonstrated new equipment by lighting the devices from off-stage controls as he talked (using a walkie-talkie). Climax of his demonstration of the new colors of fluorescent lamps was a huge floral map of the U. S. and a charming model. Said Mr. Rodgers —"This has been a good year in light."

DR. E. F. LOWRY (right) receives Fellow pin and certificate from Pres. Goddard.

MEDAL AWARD

Special ceremonies, following the opening session, attended the presentation by President Goddard of the I.E.S. Gold Medal to William F. Little of the Electrical Testing Laboratories, Inc., New York City. Mr. Little, a Past President and Fellow of the Society, has been identified with the lighting field since 1903 and has been active in the Society for more than a quarter of a century. (For a full report of his many meritorious achievements, leading to the award of this highest I.E.S. honor, see ILLUMINATING ENGINEERING, March 1950, page 199). The Medal and Certificate were presented to Mr. Little with the following citation:

"25th President and Fellow of the Society; devoted and influential worker in the councils and technical activities of this and numerous other technical societies; United States Representative on International Commission on Illumination and Chairman of its Committee on Visual Photometry; Director and Manager of Lighting, Photometric, and Related Services of Electrical Testing Laboratories, Inc.

"His nearly half-century of achievement in the development of equipment and standards for measurement and testing of light have made him a dominant authority in these phases of the lighting arts and sciences. Effective worker in many different fields of applied lighting, his influence in the development of certification programs for the lighting industry has been outstanding, and in the residential lighting field his contribution was revolutionary."

The special ceremony was opened by G. W. Beals, a member of the Award Committee who spoke in place of Chairman G. K. Hardacre. Mr. Beals outlined the history and purpose of the I.E.S. Medal Award.

OTHER AWARDS

Travel Gavel

Hotly contested each year is the silver gavel and anvil awarded annually to the Section or Chapter having traveled the farthest in the greatest numbers, in percentage of the total group membership. This year's winner was the Cleveland Section, with 30 present — a tribute to President-Elect Sturrock.

The anvil is the gift of the British Columbia Section, winner of the award in 1948.

A number of Sections and Chapters of the Society have been especially successful in capturing this gavel. Those groups which have won it a substantial number of times are: New York Section—seven times; Cleveland Section—nine including last year and both west coast meetings; Southern California twice; and Rocky Mountain Section twice.

MEMBER EMERITUS certificate is presented to Frank A. Hansen (right) by Pres. Goddard.

Membership Awards

The Membership Committee was especially active this year, under the chairmanship of Gar Morse of San Francisco, with Vice-Chairman James Hull sparkplugging from the east coast the Section and Chapter competition. As part of the Conference award ceremonies, Membership Competition prizes were awarded to:

Quebec Chapter ..... First Prize $50.00
Accepted for the Chapter by G. F. Dean.
Oregon Section ..... Second Prize $40.00
Accepted by J. D. Webster, Chairman.
New Orleans Section ..... Third Prize $22.50
Accepted by H. L. Salaun, Chairman.

In the Competition for Member Grade the winners were:

West Michigan Chapter ..... First Prize $50.00
Accepted by George Korten for the Chapter.
New Orleans Section ..... Third Prize $22.50
Accepted by H. L. Salaun, Chairman.
Carolinas Chapter ..... Third Prize $22.50
Accepted for the Chapter by Roy A. Palmer.

Golf Awards

The silver Regar Cup and President Law Cup for golf competitions at I.E.S. Conferences went back in their packings to await a winner next year. No golf competitions were featured in 1950.

Technical Committee Forum

Since the I.E.S. Technical Committees and their programs constitute one of the Society's most valuable contributions to the art, the Technical Committee Forum featured at the Pasadena Conference is a highly important part of the program.

Some 31 committees presented "flash" reports of their activities. All of these reports were well presented, with a variety of novel touches including a poem by H. E. D'Andrade on Lighting and Architecture Committee, which brought the top audience response. Reports presented at the Technical Committee Forum included: Aviation Committee; Color & Illumination; Daylighting; Farms; Handbook; Illumination Performance; Industrial; Light Control; Light Sources; Ltg. & Architecture; Lighting Design; Lighting Education; Central Stations; Schools; Television; Industrial Lighting Projects (i.e., subcommittees of I.S.P.I.); Public Buildings; Maintenance; Nomenclature; Offices; Progress; Protective Lighting; Public Conveyances; Research; Residences; Sports; S.Q.Q.; Stores; Street & Highway and Testing Procedures.

Tours

Tours for both pleasure and business were for many an important feature of the Pasadena Conference.

Sixteen delegates took a midnight tour worthy of special note. At about 11 p.m. Wednesday evening following the I.E.S. Progress Report sixteen earnest members of the Street and Highway Committee and the Technical Sub-Committee of the Highway Lighting Committee Pacific Coast Electrical Association embarked on a sixty-five mile tour of street and highway lighting in Los Angeles and vicinity. Twenty-one typical installations were studied and evaluated. Light sources ranged in size from the 10,000-lumen incandescent lamps to the 21,000-lumen E.H.I. mercury lamp. Average foot candles ranged from approximately ½ on the Hollywood Freeway to 3 on Broadway, Los Angeles. Mr. A. T. Nadeau, Senior Street Lighting Engineer, City Hall, Los Angeles had taken the lead in arranging the tour and the necessary transportation. His efforts were greatly appreciated by those who were able to take this interesting trip.

Special details concerning the various points of interest compiled from this study are available from R. M. Zabel, Chairman of the I.E.S. Street and Highway Committee.

Itineraries for numerous pleasure tours throughout the vicinity were available at the Hospitality Booth, many visitors availing themselves of the unique opportunities. Some of these included trips through Sunset Boulevard to Stone Canyon, a tour of the Southern Museum to Miracle Mile, the Rose Bowl, a visit to a movie studio and many others.

Lighting Service Forum

The Lighting Service Committee made their usual fine presentation Monday evening to which all I.E.S. members and guests were invited. This year's Committee was under the chairmanship of John S. Walsh of the Pacific Gas & Electric Company with H. H. Green of General Electric Company serving as vice-chairman. Other members of the committee participating were: R. W. Butts, Maxwell Cole, R. R. Enghouser, M. A. Havenhill, H. Leland Holtman, H. G. Hrivnatz, J. E. Mueller, Philip Peeples, W. A. Stannard, H. A. Stroud, C. R. Tracy, L. C. Twitchell.

Five "Planned Lighting in Action" skits included. 1. "Aladdin and the Magic Lamp," 2. "Whistle While You Work," 3. "City Lights," 4. "The Philadelphia Story," and 5. "Light Up and Sell," presented by a distinguished cast.

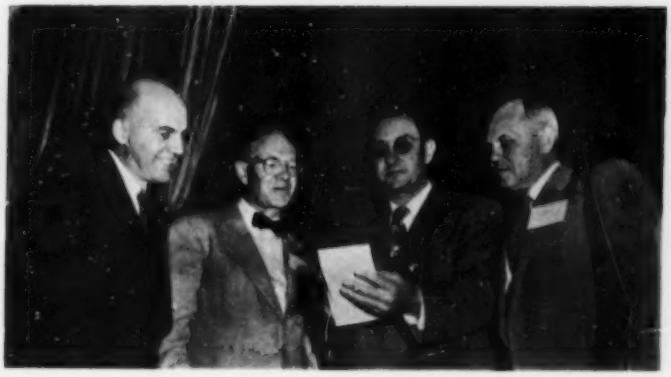
In addition to the wonderful cast, credits go to Ken Webb, the director of "Planned Lighting in Action," the stage manager, Robt. Ehorn, Staging Committee Chairman, J. H. McCullough, Script Coordination, Jim Barnes and Bill Porter, Stage Construction, Ralph Dickey and Ray Fischer and Stage Assistants, Chuck Allen, Bob Jones, Roy Kreyser and Del Reynolds.

Social Activities

The Tuesday evening Fiesta Night was a gala demonstration of Southern California history, hospitality and happiness. Mrs. Leiland Atherton Irish, a local civic leader and honorary member of the conference executive committee, set the stage for an evening of fun, music and dancing supplied by Senor José Arias troupe of 40 Mexican American singers, dancers and musicians. Mrs. Irish was assisted by Senora Consuela de Bonzo, a prominent Los Angeles woman interested in preserving the traditions of Los Angeles and its Spanish history. Included in the Fiesta program was an amusing by-play of the celebration of the breaking of the Pinata which usually is reserved for Christmas time but can be celebrated on other important holidays. The Pinata was a large paper maché replica of a lamp bulb filled with candies, etc. The contestants (Lee Tayler, Willard Brown and President Goddard) were properly blindfolded, given a large stick and told to smash the Pinata. Unbeknownst to each contestant, the Pinata was conveniently raised out of reach after he was blindfolded. Lee Tayler and Willard Brown both missed — President Goddard becoming the champion. Dancing to Spanish and modern music closed this sparkling evening of outdoor entertainment around the pool.

President's Reception

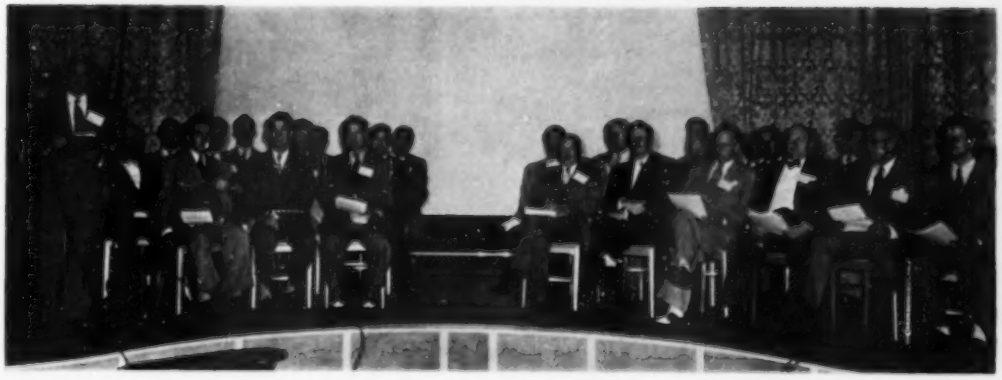
Thursday evening climaxed the 1950 Southern California National Technical Conference with the President's Reception, Banquet and Ball. President and Mrs. Goddard received their guests just above the turquoise pool in the beautiful gardens of the Huntington Hotel. Following the reception a banquet was served at tables set up around the pool. Master of Ceremonies was Don W. Prideaux, Chairman of the Conference Executive Committee, to whom is due great credit for the planning and administration of the many details of this successful meeting. Mr. Prideaux expressed his thanks to the Chairmen of the various local committees that made the conference "tick," and asked that the members of the committees also take a bow for the long hours of labor they devoted to the conference plans. Mr. Prideaux introduced, from the assembled guests, Mr. Wm. P. "Teddy" Bear, formerly a member of the Society in the San Francisco Section and still active in Southern California I.E.S. activities. Member Emeritus "Teddy" Bear though retired from business and living in San Fernando valley spent many, many hours in the preparation of the 1950 Conference on the Local Conference Publicity Committee, Transportation Committee, and even during the Conference he served for hours in the Hospitality Booth in the



THE TWO gentlemen in the upper left hand picture were some of the first personalities delegates met on their arrival at Pasadena — Roy E. Dahlin, and A. B. "Doc" Smedley, Chairman of the Hotel Committee. Lower left is Oscar Meissner (left), Chairman of Southern California Section welcoming Frank R. Knowles of Johnstown ,Pa. Directly above are four well-known personalities — Dex Hinckley, Ted Shepherd, Charlie Goddard, and Walter Sturrock.

- - - *Personalities at Pasadena* - - -

AT RIGHT — Southern California Section meets with National Officers. Seated l. to r. T. H. Shepherd, Regional V-P, Oscar Meissner, Section Chairman, Pres.-Elect Walter Sturrock, Pres. Goddard. Standing l. to r. Frank J. Rohring, Hugh X. Sheeter, W. A. McGuire, Chairman-Elect for So. Calif. Sec., R. E. Dahlin, Wm. Friend, Chas. Long, Arthur Booth, J. W. Howard, S. H. Simonsen. Directly below — the Technical Committee Forum group which presented flash reports for 31 technical committees.



A GLIMPSE of the finale of the Progress Report is given in the upper left-hand picture. Alston Rodgers is bowing out. The beautiful model is Betty Allen. Directly above is a group from the large Canadian delegation attending. At left, Committee and stage crew of the Lighting Service Forum surround Chairman John S. Walsh (center front, black tie).

IS THE refreshing group at right the I.E.S. Council of tomorrow? They are teenager sons and daughters of I.E.S. Conference delegates who had their own Pasadena program, planned and directed by Mimi Shepherd. Below left, Pres. Goddard and Pres-Elect Sturrock discuss the Past-Presidents' luncheon. The two gentlemen at bottom right were the brains behind the brains of the Conference—Don Prideaux, Exec. Chairman and Bob Hartenstein, National Chairman of the Conference Committee.

Lobby of the Hotel giving information and service to visitors and delegates.

Acknowledgment for a magnificent job went to all of the hard working committees with special mention to Miss Mary L. Salcido, who was the inspiration and genius of the highly successful Ladies' Program.

As part of the Banquet ceremonies, President Goddard also turned over the President's gavel to President-Elect Sturrock (though he "took it back" immediately as he needed it himself for official duties until he officially retired October 1st). The awarding of the Past-President's pin to President Goddard by President-Elect Sturrock enabled both to share in well deserved applause.

The colorful President's Reception and Banquet moved with stateliness into the Ball with a solo waltz by Mr. and Mrs. Goddard. Dancing outside under the stars and the beautiful Southern California moon, will be long remembered by those who came, who saw, and were conquered by the hospitality of Southern California and the success of the 1950 National Technical Conference.

Teenager Program

This year's conference scored a "first" (among others) in having a full fledged program for the teenagers who accompanied Mother and Dad to Pasadena. On Monday they investigated the facilities at the Huntington Hotel and enjoyed its beautiful pool which was kept open late for an evening swimming party complete with refreshments.

On Tuesday the Teenagers took in the Tour to "The" Farmers Market in Hollywood with the I.E.S. Ladies where they had lunch at the numerous shops and unique restaurants while craning their necks for a glimpse of famous movie stars. In the afternoon they visited the huge outdoor Greek Theatre and talked to many of the "Stars" at rehearsal. The afternoon closed with a sparkling but restful tea at the Olive Hill Foundation (Fabulous Frank Lloyd Wright designed home on the old Barnsdall Estate) and then back to the Huntington via the Arroyo Seco Parkway—nine miles of high speed four-lane highway with no crossings from Los Angeles to Pasadena. Tuesday evening the Teenagers joined the older folks at the never-to-be-forgotten Fiesta Night party. Wednesday afternoon Teenagers and I.E.S. members and wives joined in the tour to a major Movie Studio. This also was a "First"—the first such tour at a National Technical Conference. On this tour the conference registrants and guests saw how ocean scenes are duplicated on outdoor lakes, how the thousands of items of stage props are stored and cataloged, complete villages or sections of famous cities over the world and finally how a portion of a movie set is lighted in the huge sound stages. In the evening Wednesday, the Teenagers also accompanied the older folks to see Alston Rodgers give the Progress Report. On Thursday, the Teenagers had a big day all by themselves (properly chaperoned of course) on their tour to the beach at Newport with lunch at a drive-in restaurant, thence to the super Lido Isle home of Mr. and Mrs. L. E. Goit where they swam most of the afternoon, had refreshments and came back to the Huntington Hotel in time for the President's night activities. At the reception the Teenagers had their own soft drink bar and enjoyed the Banquet and Ball with the rest of the Conference attendees. During the week groups of Teenagers would form for lunch and dinner to take in a meal together at nearby interesting restaurants and colorful places to eat.

Teenagers present included: Mary Sturrock, daughter of the President-Elect; W. B. and E. W. Beggs, Jr.; Carol Bodian; Richard D. Cameron; Betsey Caroll; Hayden and Richard Carney; Janet and Marjorie Clarke; Carl Covington; Douglas and Cathryn Crouch; George R. Glass; Sue Ann Godfrey; Carol Gray; Paul and Virginia Hogan; William Jones; Ronald E. Luley; Albert H. and John L. Manwaring; Arlene Palmer and Roy, Jr.; Howard Pederson; Shirley J. Potter, D. Burr and Roy W. Prideaux; Mary Alice and William E. Schwalm; Barbara Seburn; Joyce C. Shaver; Doris, Joan and Norma Slauer; Karen Taylor; Jane and Robert Twichell; and Mary Lou Tylor.

The Teenager program was under the direction of Mimi Shepherd, daughter of Mr. and Mrs. T. H. Shepherd.

The Ladies' Program

Although the Ladies joined with the men attending the Conference and the Teenagers many times for mutual enjoyment, Miss Mary Louise Salcido, the Chairman of the Ladies' Committee together with her many committee members had an interesting program for the ladies every day of the Conference.

Monday afternoon after registration the ladies took a leisurely tour of Pasadena and surrounding communities to visit and see some of the charming homes and estates, the famous Henry E. Huntington Library and Art Gallery, the Mission San Gabriel, the Rose Bowl, and many other interesting sights. On Tuesday they took buses to "The" Farmers Market in Hollywood by way of the old Mexican street of interesting shops—Olvera Street—and the fabulous "Miracle Mile" on Wilshire Boulevard. Lunch was interesting at the Farmers Market because of the variety of specialty restaurants serving food of all types and from many foreign countries. In the afternoon a delightful tea was served by Mrs. Leiland Atherton Irish and her hostesses at the intriguing Olive Hill Foundation—the former Barnsdall Estate home designed by designer Frank Lloyd Wright.

On Tuesday evening the Ladies joined in the Fiesta Party with their colorful peasant costumes. Some of the more authentic Spanish costumes were exceptionally lovely and naturally beautifully worn to add a dazzling sparkle to the

THE 1951 Conference is already being planned. Pointing the way, at a special display at Pasadena are G. W. Clark, Harry Grattan and D. C. Freeman of the Capital Section, Washington, D. C.

SOCIAL ACTIVITIES of the Conference are brought to a memorable climax at the President's Banquet and Ball held by the sides of the beautiful Huntington Hotel pool.

festivities. The shouts of "Fiesta" rang out throughout the evening as the exuberant throng joined in celebration.

Wednesday morning was free for rest and visiting but in the afternoon all joined in the Movie Studio Tour (See Teenager program for details). Wednesday evening saw a large turnout for the Progress Report.

Thursday was another busy day for the visitors, with a scenic tour to the Pacific Ocean at Santa Monica along the coast and up through fashionable Bel-Air (home of many famous Los Angeles people) to the Los Angeles Dept. of Water and Power's Stone Canyon. This Canyon is a veritable paradise of flowers and vegetation and allowed a cool refreshing interlude while lunch was prepared including sandwiches served from an electronic cooker as fast as they could be placed into the machine. The Ladies returned to the Huntington Hotel via Hollywood and thence up the Arroyo Seco Parkway. Time was allowed for a pleasant rest and relaxation period before the climactic festivities of the President's night Reception, Banquet and Ball.

The Ladies' Committee were the originators of the idea to have the Fiesta night and to them goes much credit for its planning in addition to the many activities exclusive with the ladies' program. Many local ladies spent many hours sewing the colorful silk sashes supplied to each man as he entered for the Fiesta Party.

Conference Statistics

Official registration at the 1950 Conference was 558, of whom 230 were ladies and children.

Gavel award for miles traveled and percentage of membership went to Cleveland Section, with 30 present. Second in the gavel contest was Toronto with 12 members; third place was Central New York Chapter with four members present; fourth was Pittsburgh Section who had 10 members present.

Ten members from the New England Section traveled over 3000 miles—farthest of any, except Mr. A. H. Olson from London, England, and André Closset, from Belgium.

Southern California had the largest number registered with 104 members; Northern California next with 33. The western area of the country was well represented with members present, in addition to California, from Oregon Section, Puget Sound, Inland Empire, Utah and Rocky Mountain Section.

Canada had over 40 people in attendance—seven members from British Columbia, two from Montreal, twelve from Toronto, plus all their accompanying families. When a local Los Angeles reporter for the *Toronto Star* who wanted to interview the Toronto group saw them all piling into the publicity headquarters seemingly in droves, he hastily reconvened in the lobby of the hotel so they could all get into the same room.

IES Capades

The thanks of all the delegates go out to the hardworking crew from Electrical West Magazine (Wm. "Bill" Cyr and Walter Heston) and Oscar Meissner's local Southern California Section for the daily IES Capades. This daily Conference news sheet provided up to the minute changes, humor about the registrants, bits of news, and much enjoyment throughout the Conference.

Special Acknowledgments

Special acknowledgment should be made to the Los Angeles Department of Water and Power and the Southern California Edison Company who furnished many leaders, time and facilities to make the Conference a success, to the Southern California Section for supplying the men on the various local committees, and to its Chairman—Mr. Oscar Meissner, to Mr. T. H. Shepherd, the South Pacific Coast Regional Vice-President, and last but not least to the splendid local guidance and direction of Mr. D. W. Prideaux of the General Electric Company as Chairman of the Conference Executive Committee and the national thinking and guidance of the Chairman of the National Technical Conference Committee—Mr. R. F. Hartenstein of the Ohio Edison Co.

To acknowledge all those responsible for the fine conference this year would be an enjoyable but long task. The success of any large undertaking such as this conference depends on the work of many hands, and many people did contribute much time and valuable talent. Saludos Amigos—to all those who had a hand in making this 1950 Conference a success. For the record, some of them are:

National Technical Conference Committee

R. F. Hartenstein, Chairman; R. W. Butts, Vice-Chairman, A. I. Benedict, R. R. Brady, Harry Gratten, Jr., A. D. Hinckley, K. E. Hollingsworth, C. C. Keller, R. E. Lange, A. L. Perdue, D. W. Prideaux, T. H. Shepherd, A. E. Simpson, H. P. Steele, L. W. Towner, J. S. Walsh.

Conference Executive Committee
D. W. Prideaux, Chairman; Edward Balogh, Roy E. Dahlin, Leonard A. Hobbs, S. H. Simonsen, Leonard W. Towner.

Corresponding Members
W. E. Potter, J. S. Walsh.

Honorary Member
Mrs. Leland Atherton Irish.

Conference Committee Chairmen
Hotel: A. B. Smedley, Chairman; Merle Potter, Harry Shearin.

Registration: Russell W. Cole.

Stage and Properties: James H. McCulloch, Chairman; C. A. Bakely, Bill Bracken, Bruce Campbell, Robert Ehorn, Joseph G. Grosch, Clyde C. Laws, O. W. Sailer.

Publicity: J. Walter Howard, Chairman; Wm. P. Bear, Frank Blackwell, Barney Deramus, J. H. Hochenauer, Roy Kreiser, Wm. A. McGuire, F. Rohring.

Transportation: J. M. Smith, Chairman; Wm. P. Bear, Robert Harris, H. E. Riggs, Frank VanGilluwe.

Finance: Don K. Grandey, Chairman; Art Booth, Hugh Sheeter.

Entertainment: W. L. Friend, Chairman; H. H. Allison, F. E. Blair, J. Diffenwierth, John Doyle, Hugh Sheeter, B. R. Taylor.

Sports Advisory: R. E. Mann, Chairman; Tex Raisen, Assistant.

Lighting Display & Decoration: Louis D. Black, Chairman; Don Marsh, F. B. Nightingale, Jack Ritchie.

Attendance: Matt A. Cabot, Chairman; Chas. K. Long, James Maule, Mirko Rudman, John Sankewitch.

Ladies Reception: Miss Mary L. Salcido, Chairman; Mrs. W. A. Alden, Mrs. H. H. Allison, Mrs. E. L. Bettannier, Mrs. W. W. Bracken, Mrs. C. I. Brady, Mrs. Mac Bodian, Mrs. R. E. Dahlin, Mrs. R. J. Delander, Mrs. L. J. Doyle, Mrs. W. L. Friend, Mrs. D. K. Grandey, Mrs. E. C. Herron, Mrs. L. H. Hobbs, Mrs. J. W. Howard, Mrs. E. A. Hutchinson, Mrs. R. H. Kreyser, Mrs. C. B. Long, Mrs. L. W. Luley, Mrs. Esther Wellman, Mrs. J. H. McCulloch, Mrs. O. W. Meissner, Mrs. S. B. Morris, Miss Irene Parsons, Mrs. D. W. Prideaux, Mrs. F. J. Rohring, Mrs. G. R. Rounsavelle, Mrs. J. P. Sankewitch, Mrs. H. L. Schreiner, Mrs. H. X. Sheeter, Mrs. T. H. Shepherd, Mrs. S. H. Simonsen, Mrs. J. M. Smith, Mrs. L. W. Towner, Mrs. M. Souden Walsh.

Papers Committee: Hoyt P. Steele, Chairman; H. W. Horn, Vice-Chairman; R. D. Bradley, C. I. Brady, P. H. Hildebrand, K. M. Reid, H. L. Wright, R. M. Zabel.

Lighting Service Committee: J. S. Walsh, Chairman; H. H. Green, Vice-Chairman; R. W. Butts, Maxwell Cole, R. R. Enghouser, M. A. Havenhill, H. Leland Holtman, H. G. Hrivnak, F. E. Meuller, Philip Peeples, W. A. Stannard, H. A. Stroud, C. R. Tracy, L. C. Twichell.

LIGHTING CALENDAR

Society Events

October 12, 1950—Meeting of I.E.S. National Council, New York, N. Y.

October 26-27, 1950—Northeastern Regional Conference, Hotel Statler, New York, N. Y.

December 14, 1950 — Meeting of I.E.S. National Council, New York, N. Y.

March 4-6, 1951 — Southwestern Regional Conference, Corpus Christi, Texas.

March 13-16, 1951 — South Pacific Regional Conference, San Francisco, Calif.

March 19-24, 1951—Pacific Northwest Regional Conference, Spokane, Wash.

April 9-10, 1951—Southern Regional Conference, Miami, Fla.

May 9-12, 1951—Canadian Regional Conference, Chateau Frontenac, Quebec.

May 14, 1951—Midwestern Regional Conference (Hotel and City not yet announced).

May 21, 1951—Great Lakes Regional Conference, Cincinnati, Ohio.

Industry Events

October 11-14, 1950 — International Association of Electrical Leagues, 15th Annual Conference, Copley Plaza, Boston, Mass.

October 11-14, 1950 — The Electro-chemical Society Inc., 98th Meeting, Statler Hotel, Buffalo, N. Y.

October 13-14, 1950 — Electrical Inspectors Association of British Columbia, Annual Convention, Hotel Georgia, Vancouver, B. C.

October 16-20, 1950 — 38th National Safety Congress & Exposition of the National Safety Council, Chicago, Ill.

October 17-20, 1950 — National Electrical Contractors Association, Annual Convention, Hotel Biltmore, Los Angeles, Calif.

October 18-20, 1950—National Farm Electrification Conference, Melbourne Hotel, St. Louis, Mo.

October 19-21, 1950 — Institute of Power Engineers, 1950 Convention, Windsor Hotel, Montreal, Canada.

October 23-27, 1950 — American Institute for Electrical Engineers, Fall General Meeting, Skirvin Hotel, Oklahoma City, Okla.

October 23-27, 1950 — 1950 National Business Show, Grand Central Palace, New York, N. Y.

November 13-16, 1950 — National Electrical Manufacturers Association, Chalfonte-Haddon Hall, Atlantic City, N. J.

November 26 - December 1, 1950 — The American Society of Mechanical Engineers, Annual Meeting, Hotel Statler, New York, N. Y.

November 27-29, 1950 — American Standards Association, Annual Meeting, Waldorf-Astoria Hotel, New York, N. Y.

November 27 - December 2, 1950—Power Show, Grand Central Palace, New York, N. Y.

December 3-6, 1950 — The American Society of Refrigerating Engineers, 46th Annual Meeting, Hotel Commodore, New York, N. Y.

December 26-30, 1950 — 117th Meeting of the American Association for the Advancement of Science, Cleveland, Ohio.

January 15-18, 1951 — Plant Maintenance Show, Cleveland, Ohio.

January 22-26, 1951—Winter General Meeting, American Institute of Electrical Engineers, New York, N. Y.

March 5-9, 1951—Spring Meeting and Committee Week of the American Society for Testing Materials, Cincinnati, Ohio.

March 12-15, 1951 — National Electrical Manufacturers Association, Edgewater Beach Hotel, Chicago, Ill.

April 2-5, 1951 — The American Society of Mechanical Engineers, Spring Meeting, Atlanta, Ga.

April 2-5, 1951 — 17th Annual Sales Conference, Edison Electric Institute, Edgewater Beach Hotel, Chicago, Ill.

June 4-7, 1951 — Edison Electric Institute, Denver, Colorado.

Technical Program

Opening Session

Monday, August 21, 1950

R. F. Hartenstein, Chairman

Address of Welcome—Samuel B. Morris, Dept. of Water & Power, City of Los Angeles.

Report of General Secretary—A. H. Manwaring, Philadelphia Electrical & Mfg. Co.

President's Address—C. H. Goddard, Sylvania Electric Products, Inc.

Our Society in 1950-51—Walter Sturrock, General Electric Co.

Presentation of I.E.S. Medal to William F. Little by President C. H. Goddard.

Technical Session—General

Monday Afternoon August 21

Willard C. Brown, *Chairman*

Howard L. Wright, *Discussion Organizer*

Appraisal of Modern Fluorescent Office Lighting Systems—George J. Taylor, Day-Brite Lighting, Inc.

Light and Agriculture—J. P. Ditchman, General Electric Co.

A. C. Fluorescent Lighting for New York City's Subway Cars—E. W. Beggs, Westinghouse Electric Corp.

Muscle Action Potentials as Related to Visual Tasks in Industry—Willard Allphin, Sylvania Electric Products Inc.

Experienced Studies of Louvered Ceilings in Department Stores—Robert Wylie, Sylvania Electric Products Inc.

Technical Session—Sources

Leland H. Brown, *Chairman*

Kirk M. Reid, *Discussion Organizer*

Glow Switch Transients for Starting Fluorescent Lamps—F. H. Rixton, Westinghouse Electric Corp.

Reflector Contours for Pressed Glass Lamps—P. F. Dietz, Westinghouse Electric Corp.

New Glass Developments in the Field of Illumination—Dr. W. W. Shaver, Corning Glass Works.

Recent Development in High Wattage Reflectorized Tungsten Lamps—R. G. Slauer, Sylvania Electric Products Inc.

Bulb Sizes for Incandescent Filament Lamps—W. E. Anderson, Westinghouse Electric Corp.

Thermionic Cathodes for Fluorescent Lamps and Their Behavior—Dr. E. F. Lowry, Sylvania Electric Products Inc.

New Photochemical Lamps—L. E. Barnes, Westinghouse Electric Corp.

Technical Session

Residence Lighting

Tuesday, August 22, 1950

Lee E. Tayler, *Chairman*

C. I. Brady, *Discussion Organizer*

Lighting for the Home Sewing Machine—Myrtle Fahsbender, Priscilla Presbrey, Westinghouse Electric Corp.

Lighting the Home of Today and Tomorrow—N. H. Vacha, John C. Virden Co.

THE COUNTRY'S first mine lighting clinic, an exploratory meeting to evaluate the problems of coal mine lighting, was held at Nela Park this summer, sponsored by the National Coal Association. The twenty-eight people attending (above) were from all parts of the country, representing the U. S. Bureau of Mines, State Mining Departments, the United Mine Workers, American Mining Congress, American Standards Association, and a number of mine equipment manufacturers and utilities. Chairman for the meeting was Gwilym F. Prideaux, mine lighting specialist at Nela Park.

Fluorescent Lighting in the Home — E. W. Commery, Kaye Leighton, General Electric Co.

Residence Lighting Forum—What It Is and What It Does — Priscilla Prenbrey, Chairman Residence Lighting Forum Committee.

The Garden After Twilight—F. B. Nightingale, Kim Mfg. Co.

TECHNICAL SESSION—STREET LIGHTING

Tuesday Morning, August 22

Dr. Rolland M. Zabel, *Session Chairman*

Effective Practice in Lighting Unusually Hazardous or Irregular Roadway Areas — R. M. Sweetland, J. S. Lindsay, General Electric Co.

Lighting of the Brooklyn Battery Tunnel — Leo Greneau, Triborough Bridge & Tunnel Authority, New York and Kirk M. Reid, General Electric Co.

Temperature Problems in Street Lighting Luminaires — H. W. Loehr, Westinghouse Electric Corp.

Lighting of the Mystic River Bridge—Walter J. McClain, J. E. Greiner Co.

Uniformity of Illumination in Highway Lighting—Prof. D. M. Finch, University of California and A. E. Simmons, California Department of Public Works.

TECHNICAL SESSION—GENERAL

Tuesday Afternoon, August 22

A. F. Wakefield, *Chairman*

R. D. Bradley, *Discussion Organizer*

Functional Lighting in Canadian Church Buildings—H. C. Jones, Canadian General Electric Co.

A Method of Testing and Evaluating Fluorescent Luminaires—Kurt Franck, Holophane Co., Inc.

Lighting the School Auditorium and Stage — C. J. Allen, General Electric Co.

Effect of Task to Surround Brightness Ratios on Visual Performance—Prof. R. L. Biesele, Jr., Southern Methodist University.

Specifications of Color Rendering Properties of Fluorescent Lamps—Chas. Jerome, Sylvania Electric Products Inc. and Dr. Deane B. Judd, National Bureau of Standards.

TECHNICAL COMMITTEE FORUM

Wednesday Morning August 23

Walter Sturrock, *Chairman*

Technical Committee Program—Walter Sturrock, General Electric Co.

Flash Reports — Technical Committee Representatives.

Procedure in Developing Lighting Recommendations for the Canning Industry — C. O. Martin, Benjamin Electric Mfg. Co.

New Basis for the Design and Application of Lighting for the Home—E. W. Commery, General Electric Co.

Methods and Measurements — C. L. Crouch, Technical Director, Illuminating Engineering Society.

PROGRESS REPORT

Wednesday Evening, August 23

Alston Rodgers, *Chairman*

TECHNICAL SESSION—AVIATION LIGHTING

Thursday Morning, August 24

Theodore H. Shepherd, *Chairman*

Harry W. Horn, *Discussion Organizer*

Daylight in Classrooms—Multilateral Lighting —Prof. R. L. Biesele, Jr., Southern Methodist University.

Comfortable Brightness Relationships for Critical and Casual Seeing—S. K. Guth, General Electric Co.

The X Factors in Fluorescent Lighting—Benjamin S. Benson, Jr. and Eric H. Church, Benjamin Electric Mfg. Co.

Measurement of Visibility—Dr. C. L. Cottrell, Cornell University.

Electroluminescence—A New Process for Producing Light—Eric Mager, Dr. E. Payne, Chas. W. Jerome, Sylvania Electric Products, Inc.

PRESIDENT'S RECEPTION

Thursday Evening, August 24

Nominees for I.E.S. Gold Medal Award Invited

Members of the Society are invited to submit nominations for consideration by the 1950 Medal Committee. The current rules guiding the operation of the Medal Award Committee are included in the Society's Procedures and Policies Manual and include the following:

"Candidates for the award need not be members of the Society, nor citizens of the United States or Canada, and may be nominated at any time by any member of the Society, by presenting the Committee on Award the name of the individual whose accomplishments in his field are deemed worthy of such recognition. Each nomination should be accompanied by a comprehensive statement of the candidate's achievements, whether it be in the field of engineering, education, or administration and management.

"In order for a candidate to be considered for the award of a given year, the following shall be delivered at the General Office before January 1 of that year:

a. A letter requesting consideration of the proposed candidate.

b. A statement of the candidate's achievements on which the recommendation is based. This statement shall be signed by the person responsible for the information, not necessarily a member of the Society."

Previous awards of the I.E.S. Gold Medal established in 1944 have been made to —

George H. Stickney
Preston S. Millar
E. C. Crittenden
Matthew Luckiesh
Sir Clifford Paterson
Ward Harrison
William F. Little

The I.E.S. Medal is awarded for the purpose of giving recognition to meritorious achievement which has conspicuously furthered the profession, art or knowledge of illuminating engineering. Accomplishment thus recognized may be in the field of engineering, design, applied illumination, optics, ophthalmology, lighting research, education or administration and management.

Nominations should be sent to the I.E.S. Medal Committee in care of the General Office of the Society. Inquiries concerning nominations may be addressed to A. D. Hinckley.

Co-ordinated Classroom Seminar

On August 21 22 23, fifty representatives of education, architecture, and illuminating engineering gathered together at Pacific University, Forest Grove, Oregon, for a seminar in Co-ordinated Classroom Planning. One of several seminars on illumination held in recent months by the university, the program was organized around lectures presented by Dr.

Darrell Boyd Harmon, Texas educator, who now practices as a consultant for school systems and architects and who serves as Visiting Professor of Education to Pacific University.

Greetings were presented to the group by Dr. Walter C. Giersbach, President of Pacific University, Edwin T. Ingles, Vice-President and Head of the Education Department, and by Edward S. Johnson, General Division Manager, Portland General Electric Company which cooperated in the development of this seminar. Dr. Richard Feinberg, Dean of the College of Optometry and Director of the Institute of Visual Sciences was chairman of the seminar.

A joint discussion by Drs. D. B. Harmon and Richard Feinberg on Vision and Learning launched the program. Dr. Harmon spoke on such problems as the development of hazards of the school, problems of classroom lighting, equipping the classroom, and planning the co-ordinated classroom. Demonstrations and exhibits were presented. Other speakers on the program were Dr. Harold M. Haynes, Visual Training Laboratory, College of Optometry, Pacific University, who spoke on the subject of The School Child and His Visual Environment; Mr. Abbott Lawrence, Portland architect, who spoke on the Architect's View of Lighting; and Mr. James L. Turnbull, School Building Consultant, Oregon State Department of Education. Particular emphasis on discussion was noted throughout the seminar.

Pacific University has plans for scheduling similar workshops periodically.

MODERN illumination is a feature of new Diesel rail-cars in Colombia, South America. Similar to the installation in effect on the New Haven railroad, the lighting features aisle and individual seat units, using 40-watt, 64-volt incandescent lamps.

Deadline Set for 1951 Conference Paper Outlines

The I.E.S. Papers Committee has announced that a deadline date of February 1, 1951 has been established for the receipt from authors of outlines of their proposed papers for the 1951 National Technical Conference at Washington, D. C. Outlines received from authors after this date may not receive consideration. Outlines of proposed Conference papers should be mailed (by February 1) to: Hoyt P. Steele, Chairman Papers Committee, % Benjamin Electric Mfg. Co., Des Plaines, Illinois.

After a prospective author receives a tentative approval of the outline for his proposed paper he will be expected to mail his manuscript to the Chairman of the Papers Committee by April 1, 1951.

It has been necessary to establish these firm deadline dates in order to give proper time for publication and for serious consideration by potential discussors. A rigid publication schedule makes any later dates impossible, especially in 1951 when the National Technical Conference is scheduled for the week of August 27.

Blackout and Dimout Procedures Reviewed

Shortly after the last war, a special I.E.S. Committee on Wartime Lighting Practices during World War II prepared a rather comprehensive Engineering Digest of Defense Lighting, and a Review of Blackout and Dimout Lighting Practices. Scope of the special committee was to "solicit, assemble and compile a record of studies and practices on dimouts, blackouts and defense lighting (including concealment, camouflage and other topics) related to World War II experience, and to file such a record at the I.E.S. Headquarters."

In view of the current world developments, the Society's foresightedness in filing such a record may be of particular interest. The record covering both civil and military practice, is assembled in 48 pages of multilithed material, available from I.E.S. Headquarters for a price of $1.00.

Battery Group Changes Name

Gould-National Batteries, Inc., became the new name of the National Battery Company on August 1 when the stockholders of the latter firm approved the change proposed by the Board of Directors.

The same sales and field engineering organizations will now operate under the new name of Gould-National Batteries, Inc. Sales and field engineering headquarters for this group will continue to be located in Trenton, New Jersey.

The policies, management and operation of Gould-National Batteries, Inc., will remain the same as those followed heretofore by Gould and by National.

National Battery Company entered the industrial storage battery field through the purchase of the Gould Storage Battery Company, which was founded in 1898. The position of National in the industrial battery field was materially strengthened by the purchase, in June 1947, of the equipment and industrial battery business of Philco Corporation, with a plant located in Trenton, New Jersey.

About People

Four organizational changes at General Electric Company's Lighting and Rectifier Divisions at Lynn, Mass., have been announced by Fred D. Crowther, manager of sales of the divisions. They include the appointments of **J. P. Rutherford** as assistant manager of sales, Lighting and Rectifier Divisions; **R. J. Swackhamer** as sales manager, Street Lighting and Traffic Control sales; **D. T. Carter** as sales manager, Airport and Floodlighting sales; and **E. W. McKenzie**, assistant to the manager of sales, Lighting and Rectifier Divisions.

A. C. Monteith, vice-president in charge of engineering for the Westinghouse Electric Corp., announced recently that Benjamin Garver Lamme scholarships have been awarded to two outstanding Westinghouse engineers, **E. A. DeZubay** of Pittsburgh and **G. W. Hardigg** of Philadelphia. Mr. DeZubay is a a research engineer in the Westinghouse Research Laboratories at East Pittsburgh, while Mr. Hardigg is a design engineer in the Company's Aviation Gas Turbine Division at South Philadelphia.

Howard Luray is heading Sylvania Photolamp Division activities, with **Burley T. Cram** as Service Manager, at Emeryville, California. This is the location of a new Pacific Coast office building and distribution center opened recently by Sylvania Electric Products Inc.

William T. Tremmel, Westinghouse Lamp Division executive, retired September 1 after a 33-year career with the company. After serving as service

manager in the company lamp warehouses, Mr. Tremmel became manager of the lamp stocks and distribution department at Bloomfield in 1934 and since 1947 has been manager of production planning.

Malvern J. Gross, formerly vice-president of the General Electric X-Ray Corporation, in charge of engineering, has been appointed administrative assistant to Dr. Kenneth H. Kingdon, technical manager of the Knolls Atomic Power Laboratory. This was announced recently by William H. Milton, Jr., general manager of the laboratory, which the General Electric Co. operates for the U. S. Atomic Energy Commission.

IT SEEMS TO ME

To the Editor:

I have been reading an interesting article in the August issue "Sunlighting Church Windows at Night" by A. C. Sangster, (pages 498-99) and note with interest the author starts off, "as far as I know few if any stained glass church windows have ever been floodlighted from the outside."

I would like to inform you at this time that back in 1947 I redesigned the lighting of Ascension Memorial Church, County Road, Ipswich, Massachusetts. The window behind the altar depicted the Ascension of Christ in the center. this is a life-size figure of Christ surrounded on each side with His disciples kneeling around Him.

Four PAR 38 filament lamps were used, extending ten feet from the building horizontally with an even plane. Two center spots centered on the figure of Christ with their beams focused crosswise, the two outside lamps beams cross each other centered on the disciples.

The effect of this outside lighting, when all the lights are lighted at night, is that the figure of Christ stands out and the light blends out to the disciples.

The Altar is lighted by two PAR 38 floods and one PAR 38 spot. This gives 200 footcandles on the Cross and Altar.

I have designed relighting of a great number of churches in New England. As far as I know this church in Ipswich is the only one that has outside flood lighting on the Altar window.

I have been transferred to a position with this company in Miami, Fla.; now I am a member of the Southeast Florida Chapter and I hope to take up church lighting in this area. — ARTHUR L. BERGOT, *Manager, Colonial Electric Products, Miami, Fla.*

BOOKS AND PAMPHLETS

Television Booklet — A pamphlet on how to view television properly featuring lighting suggestions especially, has recently been issued by the Edison Electric Institute. Titled "Wonder What a Television Set Thinks About?", the pamphlet is available from E.E.I., 420 Lexington Ave., New York, N. Y. for two cents a copy. The lighting and other information on televiewing is presented in an amusing "comic-book" style, with "wrong" and "right" cartoon drawings which put across the idea simply and clearly.

Q-Floor Wiring — A concise resume of "why and where" to install *Q-Floor Wiring* is available in a new booklet just issued by General Electric's Construction Materials Department. Directed to the architect, electrical contractor, and building owner, the booklet explains Q-Floor and Q-Floor wiring advantages, with actual figures on savings in structural steel and foundations, as well as savings realized by the elimination of temporary planking, wooden forms, etc. Publication number is 18-110 UF.

Better Vision for Television — Attractive three-fold mailing piece written by Dr. Matthew Luckiesh, for consumer distribution through utilities, P.T.A. groups, Electrical Leagues, etc. The folder offers suggestions on how to watch television in comfort, and especially how the room should be lighted. Dr. Luckiesh's recommendations are not confined to lighting alone — other suggestions to add to televiewing enjoyment are also included.

Newspaper advertising copy and radio tie-in announcements with quantity orders of the folder may be obtained. The material is available from Foster & Davies Inc., Keith Bldg., Cleveland, Ohio. Free sample copies; quantity price on request.

Colorimetry — Scientists and technicians concerned with color measurement will find much helpful information in a new booklet, Colorimetry, recently published by the National Bureau of Standards and now available from the U. S. Government Printing Office. The present booklet describes the standards and measurement methods developed by the Bureau in this field, giving the basis for each technique and showing clearly how one method supplements the other. Chapters cover the following topics: the standard observer; illuminants and coordinate system; small-difference colorimetry; material standards of color; one-dimensional color scales; and general methods. Circular C478, Colorimetry, by Deane B. Judd, 56 large double-column pages, illustrated, 30 cents a copy, is available from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Remittance from foreign countries must be in United States exchange and must include an additional sum of one-third the publication price to cover mailing costs.

Electrical Home Planning — To meet the need for information on modern techniques in electrical planning for the home, the Better Homes Bureau of the Westinghouse Electric Corp. has published a new 24-page booklet on Design Details for Electrical Living Homes. Photographs, plan views, and wiring diagrams are used profusely to illustrate ways of best utilizing available floor space in kitchens and laundries. Several different lighting schemes are considered, all designed to beautify the home as well as provide adequate illumination. Cornice, pin-hole spot, valance, cove, recessed ceiling, and cabinet lighting plans are treated in detail, accompanied by construction drawings. It shows how unusual lighting effects, as well as good general illumination, can be achieved by the use of fluorescent tubes. The final section of the book offers an outline of the minimum requirements for providing complete electrical service in the modern home. This section, divided into three parts, includes: Outlets located to give service where wanted; Circuits of capacity to properly serve the outlets; and Service Entrance capable of carrying present and future loads. For a copy of Booklet B-4671, write Westinghouse Electric Corporation, Box 2099, Pittsburgh 30, Pa.

A new 31-page booklet describing "electrical packages" that may be used by builders and architects as strong, exclusive sales features in their homes is available from the Better Homes Bureau of Westinghouse Electric Corporation. The booklet contains numerous photographs and layout sketches of several homes designed and constructed by the Better Homes Bureau in conjunction with electric utilities, architects, and builders. Floor plans and wiring details, providing the ultimate in convenience and beauty — yet taking full advantage of the efficiency

Continued on page 16A

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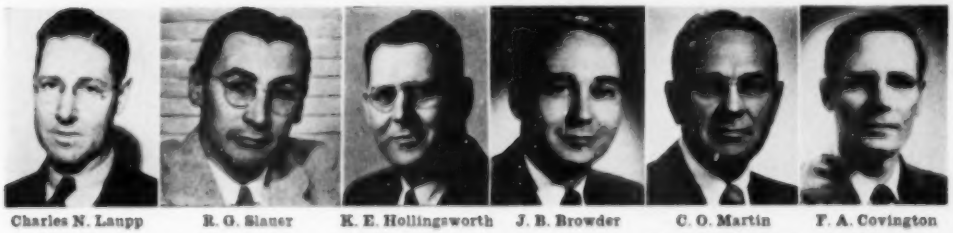

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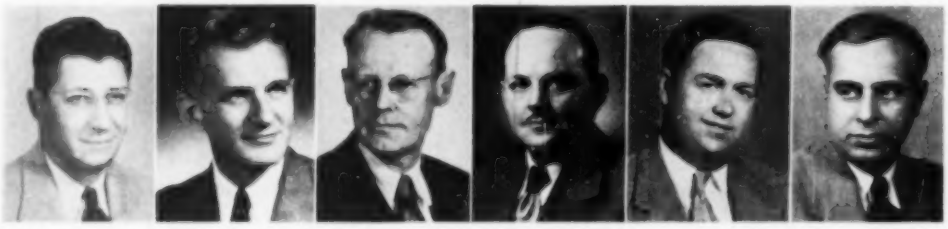

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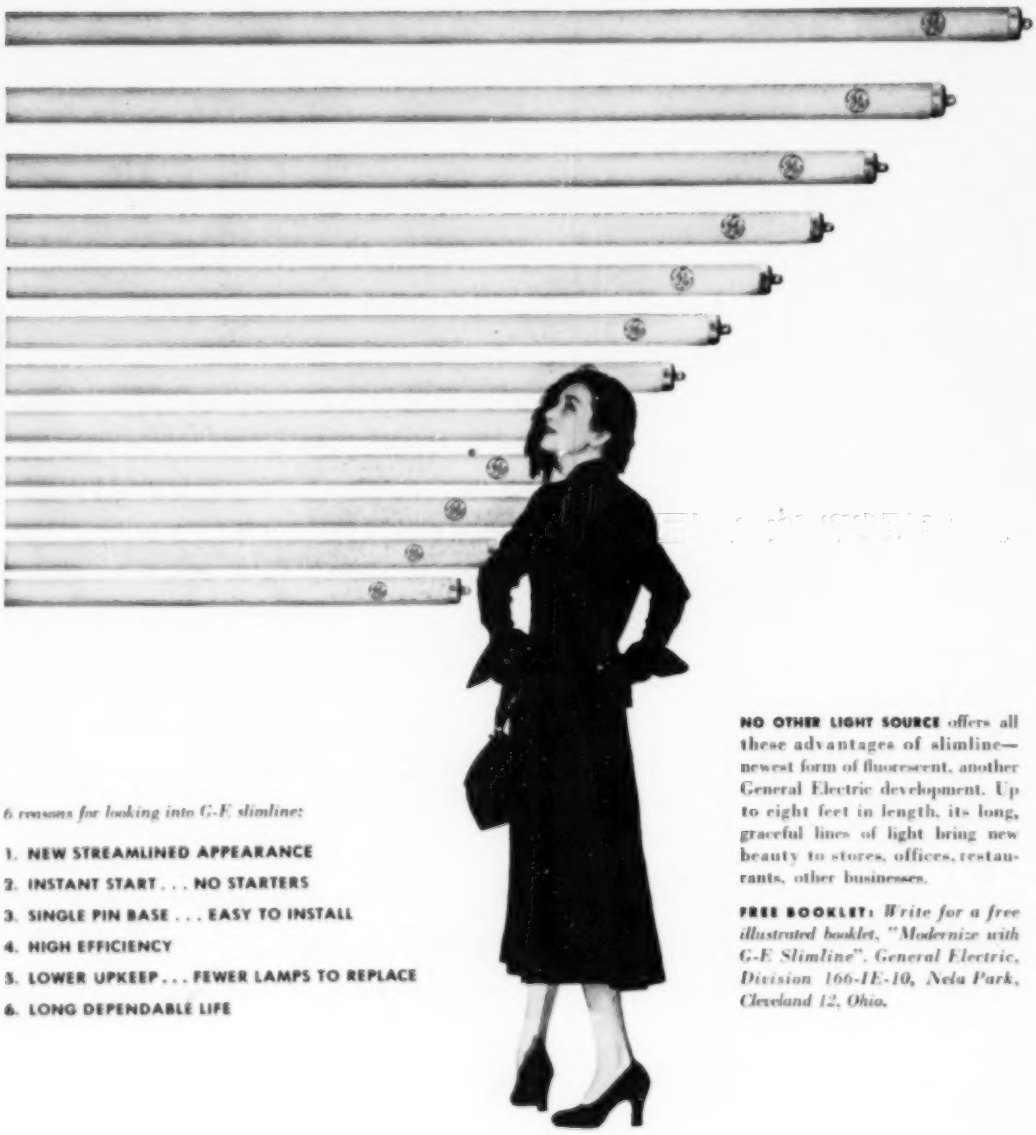
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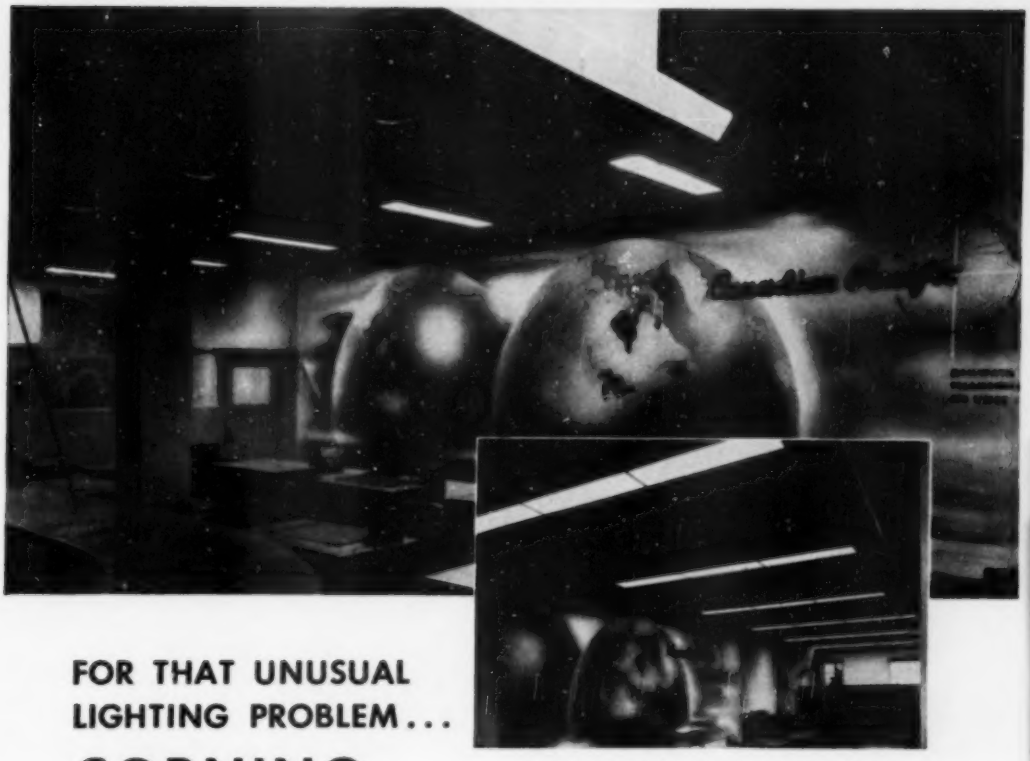


FOR THAT UNUSUAL LIGHTING PROBLEM...

CORNING FOTA-LITE

Canadian Pacific Railway Co. Office, New York, N. Y.
Architect: Rogers and Butler, New York, N. Y.
Fixture Manufacturer: Frink Corporation, Long Island City, N. Y.
Consulting Engineer: Gustave B. Weiser, New York, N. Y.
Glass: Corning FOTA-LITE

The distinctive three-dimensional effect of the mural in the New York office of the Canadian Pacific Railway didn't just happen. It is the result of well executed art and carefully planned lighting. Through judicious use of Corning FOTA-LITE the mural's highlights and shadows are properly emphasized by eliminating distracting glare.

The unique pattern of FOTA-LITE permits virtually unrestricted light transmission downward through crystal glass. The opal louvers which are integral with glass intercept and diffuse light which would cause high angle brightness. Non-color selective, FOTA-LITE transmits the true color of the light source . . . gives better quality light.

FOTA-LITE combines the advantages of louver lighting with those of diffusing glasses. The louver effect is contained within its 5/8" thickness, thus reducing bulk. The glass will not fade, warp or scratch. The smooth surface does not attract dust and is easily cleaned. FOTA-LITE is available in widths up to 23" and in lengths up to 49". For more complete information regarding this unusual glass, write to-day.

PYREX

CORNING GLASS WORKS
CORNING, NEW YORK
Corning means research in Glass

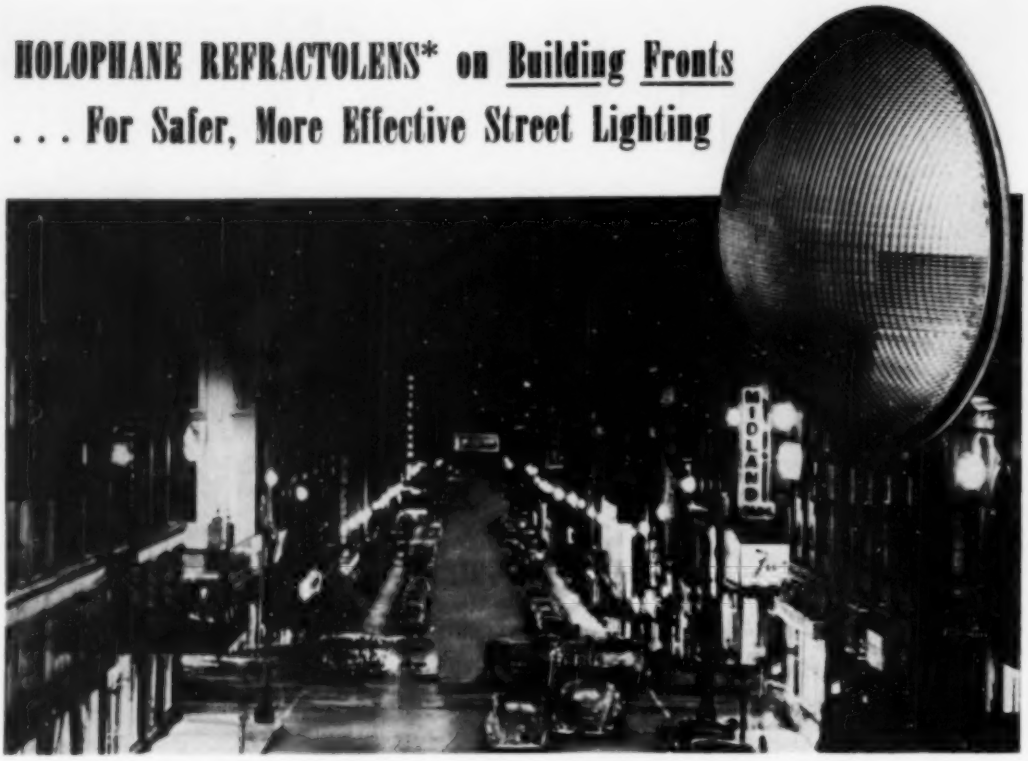
FOR EFFICIENT, ATTRACTIVE LIGHTING...
CORNING ALBA-LITE for diffusion of fluorescent light ... CORNING FOTA-LITE for high level illumination ... CORNING brand LENS PANELS and PYREX brand LENSLITES for prismatic light control

CORNING GLASS WORKS
Dept. IE-10, Corning, N. Y.

Please send me more information about Fota-Lite glass.

Name _____ Title _____
Firm _____
Address _____
City _____ Zone _____ State _____

HOLOPHANE REFRACTOLENS* on Building Fronts
. . . For Safer, More Effective Street Lighting



Street Scene, 1950 . . . In St. Paul, Minn., Business Section

26 Feet above street level . . . the Holophane Refractolens (upper-right) is mounted to the building front. The double-refracting lens (20" diameter) is designed to resist heat, shock and deterioration.

"The new lights, providing about 10 TIMES more illumination on the street, are far superior to the old lights from the standpoint of glare" . . .

From an official report of St. Paul Engineers

When St. Paul authorities envisioned an altogether new method of illuminating streets in the business section, they called in street lighting consultants. Result: the new Holophane REFRACTOLENS set into a General Electric fixture, and mounted flush to the front facades of buildings for twenty-two midtown blocks . . . Outstanding advantages: cheerful white light 10 times brighter than before; elimination of obstructive lamp posts and brackets; remarkable uniformity of light; maximum visibility for both motorist and pedestrian; reduction of night traffic accidents; stimulation of retail business . . . Holophane Street Lighting Engineers will send, without obligation, engineering data and complete details of "St. Paul's Whiteway".

*Reg. U. S. Pat. Off.

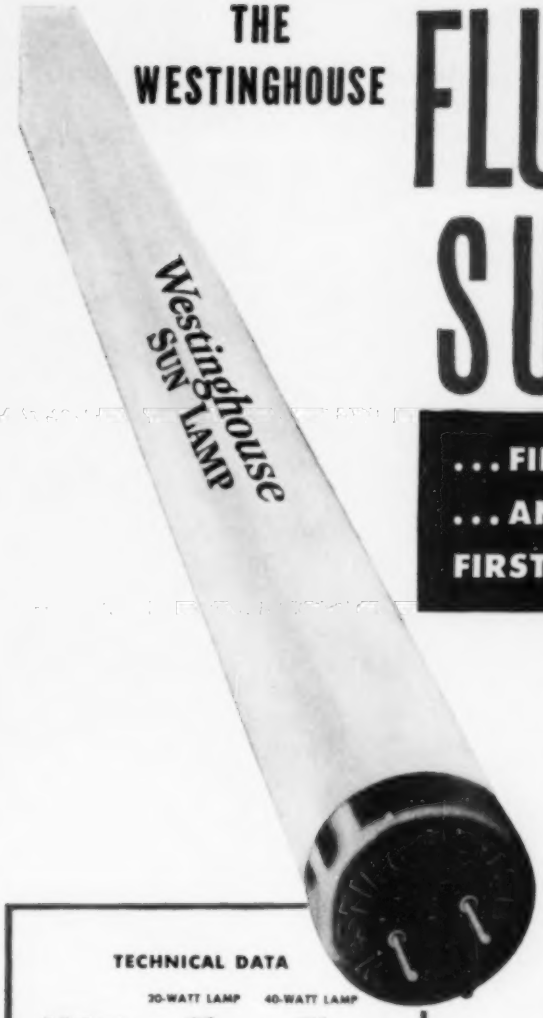
Holophane

HOLOPHANE COMPANY, Inc.

Lighting Authorities Since 1898 - STREET LIGHTING DEPARTMENT, NEWARK, OHIO

THE HOLOPHANE COMPANY, LTD., THE QUEENSWAY, TORONTO 14, ONTARIO

THE WESTINGHOUSE FLUORESCENT SUN LAMP



. . . FIRST OF ITS KIND
. . . AND FAST BECOMING FIRST FOR INDOOR SUNSHINE

Tried, tested, and accepted! That's what has happened since Westinghouse introduced its exclusive *Fluorescent* Sun Lamp a year ago. And with this first year's success, the sales future for this lamp looks brighter than ever.

There are good reasons for this acceptance. For the first time, wide areas can be bathed practically and economically with beneficial ultraviolet rays. At a relatively close range, it's ideal for tanning. Cool enough to touch, it has five times the output and four times the life of the conventional bulb-type sun lamp. It costs less to buy, less to run, and fits standard fluorescent fixtures. The market for this lamp is all around you . . . homes, offices, factories, schools, recreation centers, barber shops, beauty shops, to name a few . . . and this is *additional* business, not substitute business!

Why not cash in on this lamp's new business opportunities? *Now* is the time because Westinghouse is now launching a heavy advertising program for the sun lamp. Mail the coupon today, and we'll tell you how to tie in with a really good thing!

TECHNICAL DATA

	20-WATT LAMP	40-WATT LAMP
Bulb diameter	1½"	1½"
Lamp Length	24"	48"
Base	Medium Bipin	Medium Bipin
List Price	$4.50	$7.00

Rated Avg. Life: 2500 hours at 3 hours per start
4000 hours at 6 hours per start
5000 applications of 15 minutes per start

YOU CAN BE SURE . . . IF IT'S

Westinghouse

Lamp Division
Westinghouse Electric Corporation
Bloomfield, New Jersey

Gentlemen:
Please send your booklet on the Westinghouse Fluorescent Sun Lamp, and give me any additional information about this lamp's market possibilities.

NAME .....

ADDRESS .....

CITY ..... STATE .....

WHY TROFFERS? WHY DAY-BRITE?

There's this to say about troffer lighting: *good taste and good light!* The smart, modern appearance of recessed troffers . . . the smooth, unbroken surface of the ceiling . . . the endless variety of lighting patterns . . . all contribute an atmosphere of elegance and discrimination.

And when interiors deserve top-quality troffer lighting, there's no equal for Day-Brite troffers . . . in appearance, in quality, in true economy. Day-Brite quality is especially important, for troffer installations are permanent . . . *you must be sure of long-term, trouble-free performance before you buy!*

Six basic groups to choose from . . . each available in 96" Slimline and 48" Standard Fluorescent . . . each available in snap-in and flange types . . . each adaptable for countless geometric patterns or for unit or continuous installations. Fine lighting equipment? Yes . . . and fine lighting *value:* value that *only* famous Day-Brite quality can produce.

A COMPLETE TROFFER LINE

BOXCO LOUVERED TROFFERS

HOLOPHANE CONTROLENS* TROFFERS

HOLOPHANE CURVED CONTROLENS* TROFFERS

GLASS-ENCLOSED TROFFERS

LATERAL LOUVERED DEEP TROFFERS

PARABOLIC TROFFERS

ACCENT UNITS— FIXED AND ADJUSTABLE

*® HOLOPHANE CO.

DISTRIBUTED NATIONALLY BY LEADING ELECTRICAL WHOLESALERS

Day-Brite Lighting, Inc., 5432 Bulwer Ave., St. Louis 7, Mo.
In Canada: Amalgamated Electric Corp., Ltd., Toronto 6, Ontario

034

ONLY QUALITY IS ECONOMICAL

"DECIDEDLY BETTER"
DAY-BRITE
Lighting Fixtures

..... IN HOMES TOO

WITH G-E TRIGGER-START BALLASTS

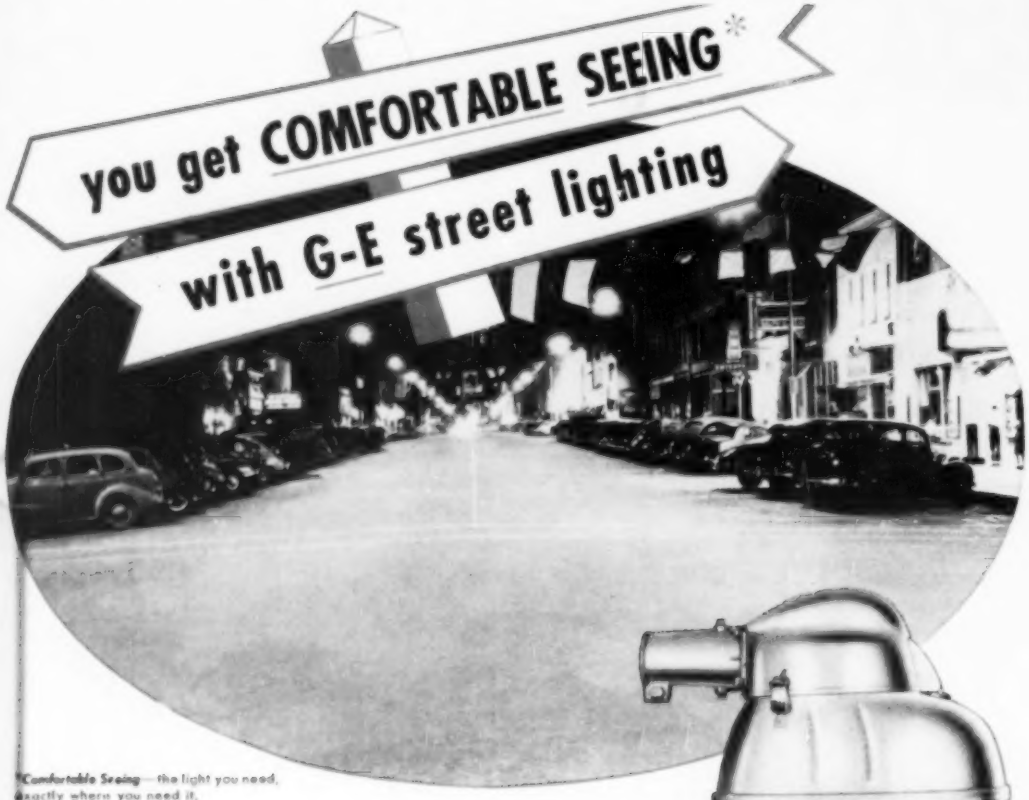
NO STARTER
NO DELAY

This Tag Sells the Story

Now, G-E trigger-start ballasts for 14, 15, 20, and 32-watt (circline) standard lamps provide instant starting in residential fixtures. And a new two-lamp trigger unit is available for standard 20-watt lamps. So now, whether it's a residential, commercial, or industrial fixture, let this tag be your sign of top quality ballasts—let it help you sell the story of better lighting, *instantly*.

GENERAL ELECTRIC

you get COMFORTABLE SEEING* with G-E street lighting



*Comfortable Seeing—the light you need, exactly where you need it, economically.

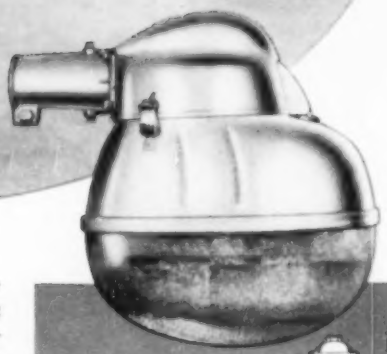
Rocky Ford, Colorado, welcomes **Comfortable Seeing**. The merchants are pleased with the business which Comfortable Seeing is stimulating. Driving is safer due to increased visibility. City officials are proud of the progressive appearance of their town. Citizens are delighted with the crisp, cool, blue-brilliant light which makes "going downtown" a pleasure. Add it all up and you have a community completely sold on **Comfortable Seeing**.

IT'S MODERN MERCURY

To make a showing after dark, economically, Rocky Ford wanted modern mercury—twice as efficient as incandescent. To get the maximum light on the street, city officials chose G-E's new trendmaking Form 109—the only street light burning the effective FH-1 16,000 lumen mercury lamp horizontally.

When you come to your relighting plans, be sure to get business-stimulating, eye-easing **Comfortable Seeing**. For your heavy-traffic streets, ask your utility or nearest G-E Apparatus Department specialist to explain the details of the new trendmaking Form 109.

Apparatus Department, General Electric Company, Schenectady 5, N. Y.



This is the Form 109

a new concept in luminaires

Notice the new and exclusive ovate triple-lateral reflector and streamlined refractor. These new design features, scientifically balanced against each other, develop new standards for utilization, distribution and glare control.

GENERAL ELECTRIC

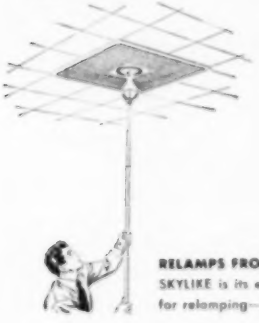
Incandescent advantages

WITH A FLUORESCENT LOOK!

The SKYLIKE System—a new concept of lighting—combines the best features of silvered-bowl incandescent lighting with the architectural advantages of a fluorescent-type troffer. SKYLIKE makes it possible for you to offer your commercial customers something dramatically different, better—and lower-cost!

In fact this new adaptation of silvered-bowl incandescent lighting provides a combination of important practical advantages not found in any other lighting system:

1. **Warm color—most desired by merchandising experts.**
2. **High initial and maintained light output.**
3. **Softly diffused shadows.**
4. **Low brightness and 90° shielding.**
5. **No flickering, blinking, or hum.**
6. **Instant starting.**
7. **Variable lamp size—150- to 500-watt.**
8. **No light loss from darkened walls or ceilings.**
9. **Floor-service relamping—no ladders or scaffolds.**
10. **Hermetically sealed silver reflecting surface.**



RELAMPS FROM THE FLOOR! One of the many features of SKYLIKE is its ease of maintenance. No stepladder is needed for relamping—a lamp changer can be used, as shown.

CONTRACTOR ADVANTAGES

SKYLIKE is good news for electrical contractors, because it has the advantages of simple wiring, light weight and fast installation, and complete freedom from service call-backs.

In addition to all its technical advantages, SKYLIKE is modern, handsome, and versatile in application. Units fit 24" x 24" ceiling tiles, fully or partially recessed, or may be surface-mounted—in rows or patterns. With a simple accessory and a semi-silvered-bowl-lamp, SKYLIKE is converted for directional or accent lighting.

AMAZINGLY LOW-COST!

Because it is so simple—simple in construction; simple in wiring; free of ballasts, starters, and accessories—SKYLIKE is low in cost (½ to ⅓ the cost of equipment delivering comparable results!) Its light weight makes for easy handling, fast installation, and lower-cost supporting construction. There's no transformer or starter maintenance. The 87% reflection factor of SKYLIKE's enamelled ceiling is easily maintained by occasional cleaning with a damp cloth.

SILVRAY

Skylike*

Send coupon for 16-page bulletin

Graybar Electric Company, Inc.
Graybar Building
420 Lexington Ave.
New York 17, New York

SILVRAY Skylike

Please send me a copy of "SKYLIKE Louvered Incandescent Lighting Systems."

Name _____ Title _____

Firm _____

Address _____

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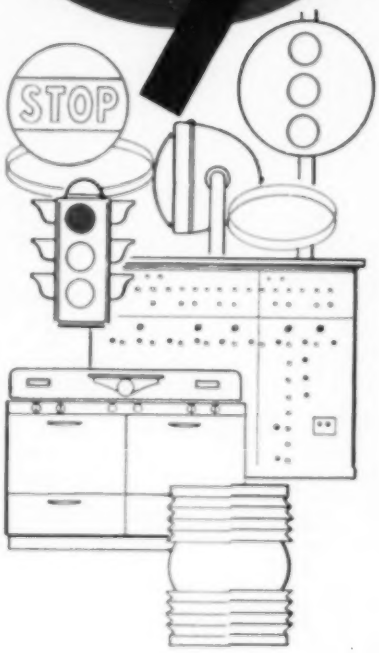
5092IE

wherever there is light

KOPP GLASS . . .

can give it meaning or direction



Kopp Glass products can play an important part in making light do your bidding; you can use Kopp lenses to diffuse, deflect or concentrate beams of light, to transmit colors, for infra-red or ultra-violet applications, for "on" or "off" lights, for all sorts of signals where uniform colors, durability and dimensional accuracy are important. Other Kopp Glass products are liquid-level sight glasses, transparent instrument cases, glass domes, panels for domestic oil burners, beads for glass-to-metal seals, direction signals.

Kopp engineers will design glass parts for your specific applications. Necessary research and development work is conducted in our well-equipped modern laboratories. Moulds are made by our experienced craftsmen, and sample glass parts throughly tested before production starts.

You can be sure of the uniformly high quality of Kopp Glass, for complete control is exercised at every step of production, from the selection of raw materials, to the testing, packing and shipping of finished product.

Use KOPP GLASS to assure complete satisfaction.

KOPP GLASS, INC.

SWISSVALE, PENNSYLVANIA

PUBLICATIONS *of the*
ILLUMINATING ENGINEERING SOCIETY

These publications summarize the studies and conclusions of technical committees of the Illuminating Engineering Society over a period of years. They contain the latest available information about many aspects of the art and science of illumination, and include details of application as well as lighting technique. Each publication listed here carries the authority and approval of the Society.

These Society publications are available in single copies for information and for lighting reference book shelves or in quantity for educational or other distribution. Each publication is numbered for ordering when using the coupon printed on the back of this page.

(1) I.E.S. LIGHTING HANDBOOK

One volume, 850 pages. A complete reference guide providing basic information on all phases of lighting. For architects, designers, engineers and others who plan, install and manufacture lighting systems and equipment. $7.50 per copy; $5 in lots of 10 or more.

I.E.S. Members who have not availed themselves at the privilege at one membership copy at $3 may still do so. Add 50c if for shipment abroad.

I.E.S. APPROVED LIGHTING PRACTICES

These booklets contain the latest official I.E.S. lighting recommendations; illustrated with charts, sketches and photographs.

(2) HOME LIGHTING Recommended Practice (1947)

(3) OFFICE LIGHTING Recommended Practice (1947)

(4) STREET AND HIGHWAY LIGHTING American Standard Practice (1947)

(5) LIGHTING PRACTICES FOR STORES AND OTHER MERCHANDISING AREAS (1948)

(6) SCHOOL LIGHTING American Standard Practice (1946)

(7) LIBRARY LIGHTING Recommended Practice (1950)

(8) DAYLIGHTING Recommended Practice (1950)

Booklets above available at 50 cents per copy or in quantity as follows: first 4 copies, 50c each; next 20, 25c each; all over 24 copies, 15c each.

(9) INDUSTRIAL LIGHTING American Recommended Practice (1942)

First 10 copies, 25c each; next 40, 20c each; all over 50 copies, 15c each.

STUDY REPORTS

Lighting recommendations based on recent studies (research, surveys of current practice, and experimental installations) of the I.E.S. Committee on Lighting Study Projects in Industry; completely illustrated. Contain analyses of seeing tasks; recommended quality and quantity of lighting; and suitable lighting methods and systems for both general and supplementary lighting.

(10) LIGHTING FOR WOOLEN AND WORSTED TEXTILE MILLS (1949)

Detailed treatment of lighting for opening and grading, carding, spinning, weaving, and perching. Much of data is also applicable to other types of textile mills.

(11) LIGHTING FOR MACHINING OF SMALL METAL PARTS (1949)

Revision of the 1939 report. Analysis of factors affecting visibility of convex scales, steel rules, scribed marks, center-punch marks, concave specular surfaces, plane and convex surfaces; general shop lighting; and supplementary lighting for various measuring instruments, bench work, machine tools, and inspection of polished surfaces.

(12) LIGHTING FOR FLOUR MILLS (1949)

Close-up photos of visual tasks and levels and quality of illumination for roll, sifter and purifier floors; packing areas; and product control stations.

(13) LIGHTING FOR CANNERIES (1950)

Recommendations based on committee study and research financed by the National Canners Association at Stanford University on general supplementary artificial lighting and daylighting for tasks common to all types of canneries; lighting for color grading and container inspection; and detailed analyses of seeing tasks and suggested lighting layouts for peach, apricot, tomato and olive canning. Data for peaches and apricots may be used as a guide for other light products; tomatoes for medium dark products; and olives for most dark colored foods. Also treated are light sources and equipment suitable for installation in canneries; glare and brightness ratios; sanitation and safety; measurement of light; and adequate electrical wiring.

(14) LIGHTING FOR BAKERIES (1950)

Committee study report on baking industry; complete with photos and drawings of typical floor arrangements and lighting layouts; paint color for visual environment; use of day lighting; lighting levels for various departments; maintenance. Also includes description of use of ultraviolet radiation.

Booklets (10) to (14) available at 35c each; quantity prices upon request.

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ILLUMINATING ENGINEERING SOCIETY
51 Madison Avenue
New York 10, N. Y.

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Please send me, addressed as below, copies of I.E.S. Publications which I have indicated by number.
☐ My check (money order) is enclosed. ☐ Bill me.

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Indicate publications wanted by number. Enter name and address. Clip out and mail.

LIGHTING DATA SHEETS

Photographs, drawings and engineering data on actual installations. Sheets punched for binders, available on lighting for metalworking, textile, automobile and other industries; schools; stores; offices; drafting rooms; churches; auditoriums; banks; museums; residences; indoor and outdoor recreational areas; and street and highway lighting.

(15) SERIES XII and XIII—24 sheets each—$1 per series.

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Delivered throughout year; first group of eight (8) sheets now available; balance in two mailings by January, 1951.

(18) SPECIAL DATA SHEET BINDER
New style, durable loose-leaf binder bound in blue fabrikoid and attractively stamped in gold. Single binder $1.50; in lots of 25 or more, $1.25.

LIGHTING COURSE MATERIAL

(19) EXPERIMENTS WITH LIGHT
Practical problems suitable for high school science classes. 25c each.

(20) LIGHTING FUNDAMENTALS
Lithograph outline for a one-semester introductory lighting course suitable for college students or adults. $1 each; 10 or more, 75c.

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Lithograph outline and data sheets for a one-semester course to follow "Lighting Fundamentals." Sections on illumination design methods, brightness ratio calculations, light sources, color in illumination, fixture design evaluation, evaluating lighting installations in the field, bactericidal and infrared energy, and design of installations for office, store, school, industrial and floodlighting. $1.50 each; 10 or more, $1.25.

(22) LESSONS IN PRACTICAL HOME ILLUMINATION
Lithograph outline of a one-semester first course in lighting for utility home lighting advisors, high school and college home economics students, decorators, architects, contractors, builders, and department store lamp department personnel. 25c each.

OTHER PUBLICATIONS

(23) TESTING PROCEDURES FOR ILLUMINATION CHARACTERISTICS (1949)
Five committee reports in one volume: guides to testing fluorescent lamps and luminaires, and street lighting luminaires. $1 per copy.

(24) STANDARD METHOD FOR MEASURING AND REPORTING ILLUMINATION FROM ARTIFICIAL SOURCES IN BUILDING INTERIORS
What to guard against in choosing instruments, where test stations are located and how to take readings. 10c each.

(25) FOOTCANDLE SURVEY (IS-10) FOR ARTIFICIAL ILLUMINATION IN INTERIORS
For use with (24) above, 2c each.

(26) LIGHTING EQUIPMENT ENGINEERING DATA SHEET
For equipment manufacturers and testing agencies for use as a guide in preparing forms for presentation of photometric and other pertinent data on lighting equipment. Also helpful to equipment purchasers as basis for required data. 10c each.

(27) BRIGHTNESS DISTRIBUTION IN ROOMS (1947)
Report #4 of Committee on Standards of Quality and Quantity for Interior Illumination. A set of 28 tables (based on interreflectance calculations) designed for predetermining the brightness of ceiling, walls, floor and furniture for 6 different types of lighting. 50c each.

(28) ART GALLERY LIGHTING (1945)
Completely illustrated guide to lighting exhibits of sculpture and paintings. First 4 copies, 50c each; next 20, 25c each; all over 24 copies, 15c each.

(29) LIGHTING PRINCIPLES AND PRACTICE
A bibliography of selected papers dealing with lighting applications which appeared in the I.E.S. Transactions from 1920 to 1941. 50c each.

(30) GUIDE FOR LIGHTING DATA SHEETS AND LIGHTING PROBLEMS
Instructions for choosing installations and taking measurements, data and illustrations required for submission of I.E.S. Lighting Data Sheets; definition and guide for preparation of I.E.S. Lighting Problems; check sheets for recording data for school, office, store and industrial lighting installations and task view. 50c each.

(31) ILLUMINATING ENGINEERING
The Journal of the Illuminationg Engineer Society. This monthly magazine contains articles on all phases of lighting of interest to lighting engineers, architects, interior decorators and ophthalmologists. Subscription price, $10 per year, plus 50c for delivery abroad; single copies, $1.50 each.

(32) RESIDENCE WIRING DESIGN HANDBOOK
25c each.

(44) FARMSTEAD WIRING DESIGN HANDBOOK
40c each.

Booklets (32) and (33) published by Industry Committee on Interior Wiring Design, Room 2630, 420 Lexington Ave., New York, N. Y. Quantity prices upon request.

Continued from page 604

of modern electrical equipment — are illustrated in the booklet. Several "electrical packages" are suggested so the builder can select those most suitable to the size, type, and price bracket of the homes he builds. User benefits have been suggested for each "electrical package" to help the builder sell his home most effectively. Also illustrated in detail is the use of special lighting schemes such as cornice, pinhole spot, valance, and cove lighting. For a copy of Booklet B-4691, write Westinghouse Electric Corporation, Box 2099, Pittsburgh 30, Pa.

A.S.T.M. Standards—With over 8000 pages, including the more than 1550 standards, specifications, tests, and definition for materials, the 1949 Book of A.S.T.M. Standards is issued in six parts. Used not only in the United States and Canada but throughout the world for purchase of materials, and particularly for evaluating their quality through the standard tests that are given, the book is made up as follows:

Part 1. Ferrous Metals
Part 2. Non-Ferrous Metals
Part 3. Cement, Concrete, Ceramics, Thermal Insulation, Road and Waterproofing Materials, Soils
Part 4. Paint, Naval Stores, Wood, Adhesives, Shipping Containers, Paper
Part 5. Textiles, Soap, Fuels, Petroleum, Aromatic hydrocarbons, Water
Part 6. Electrical Insulation, Plastics, Rubber.

Each Part of the 1949 book is complete with detailed subject index, two tables of contents, and arranged to provide the thousands of technologists and others in industry and government with as usable a book as possible.

To keep the books up to date, a supplement will be issued to *each* part late in 1950. As a service with the 1949 Book of Standards there is a complete Index to Standards, which is furnished without additional charge. (The latest 260-page Index is in course of publication, to be available about July 1950).

Prices of the 1949 Book of A.S.T.M. Standards, in blue cloth binding, red backstraps

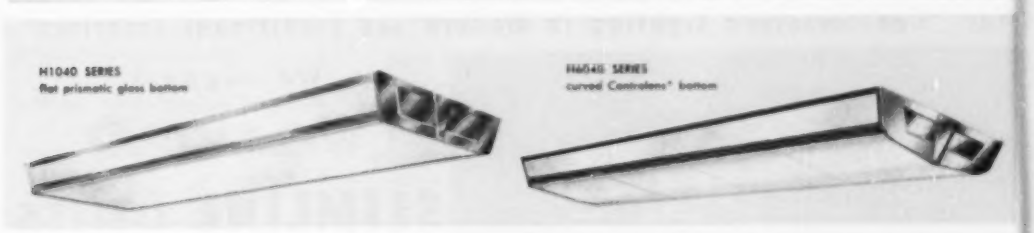
Parts 1, 5, 6	$10.00 each
Parts 2, 3, 4	8.00 each
A Complete Set of all Six Parts	54.00 set

Copies may be obtained from the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa.

The proposed American Standard Specification for **Fluorescent Lamp Ballasts**, C82.1, has just been published for a year's trial and criticism by the American Standards Association. This is the third standard in a series of proposed specifications for lamp ballasts. In addition to definitions the standard contains specifications for ballast marking, ballast performance and recommended operating temperature limits. The requirements for ballast performance cover: starting, power output, cathode preheating current, regulation, operating current wave shape, supplementary cathode heating, voltage across starter terminals, radio interference suppression, noise, ballast heating, dielectric strength, and insulation resistance.

This standard was developed by a committee representing ballast and lamp manufacturers, public utilities, testing laboratories, and government departments, under the procedures of the American Standards Association. All comments received will be considered by the committee in preparing the completed standard.

The two previous standards published in this series are the American Standard Methods of Measurement of Fluorescent Lamp Ballasts, C82.2 and the Proposed American Standard Specification for Fluorescent Lamp Reference Ballasts, C82.3. Copies of the Proposed American Standard Specification for Fluorescent Lamp Ballasts, C82.1, can be obtained from the American Standards Association, 70 East 45 Street, New York 17, N. Y. at thirty-five cents per copy.



new SUNBEAM fixtures styled for distinguished interiors

These new SUNBEAM luminaires provide controlled light distribution through hinged Controlens® and prismatic glass elements. Combining low surface brightness with a strong downward component of light, these units are completely enclosed for minimum maintenance.

Simplicity of line and generous proportions characterize these fixtures for interiors where modern dignity is the keynote. The sturdy bottom frames features a full-length piano hinge and vibration proof, spring-loaded latches. Both series available in 2, 3, and 4-lamp 48", 72" and 96" lengths.

® Holophane Co., Inc.

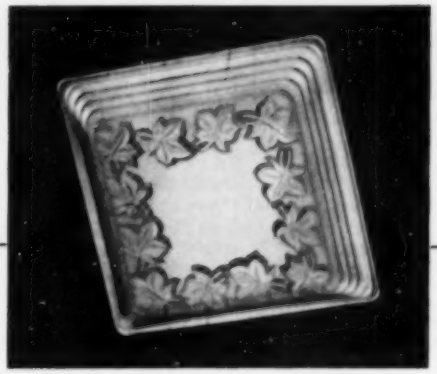
SUNBEAM LIGHTING COMPANY • 777 EAST 14TH PLACE • LOS ANGELES 21, CALIF.

PERFORMANCE THAT ASSURES BETTER LIGHT

Acme Electric ballasts have been engineered to eliminate "strobe" effect, provide more lumen output, longer lamp life, quiet operation. Their better performance assure your customer's satisfaction.

ACME ELECTRIC CORPORATION
2910 WATER STREET CUBA, N. Y.

Acme Electric
TRANSFORMERS



No. 1442 8" x 8" x 1⅝"

DUNBAR Recessed Lens

For the first time, here are recessed drop lenses which give *added* light. In addition to the general downward illumination, light is directed horizontally to increase the efficiency of this type of fixture.

Dunbar's designers, J. O. Reinecke and Associates, have created several new decorative panels for residential as well as commercial installations.

See them at your nearest Dunbar office, or write direct for further information.

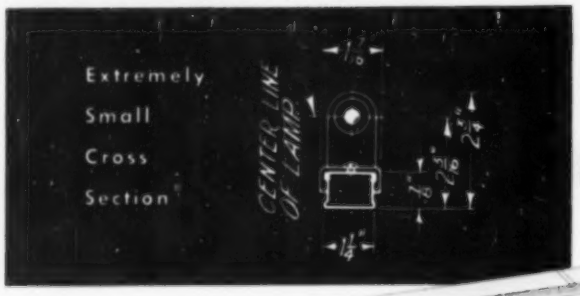
Dunbar Glass Corporation

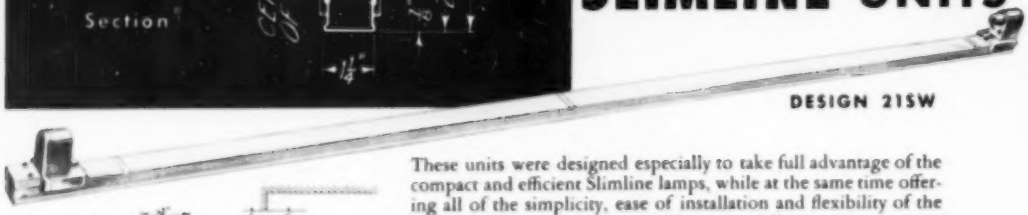
DUNBAR, WEST VIRGINIA
NEW YORK CHICAGO CLEVELAND LOS ANGELES

for "Contemporary Lighting in Modern *and* Traditional Interiors"

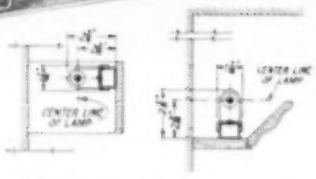
We suggest

WIREMOLD SLIMLINE UNITS





DESIGN 21SW



These units were designed especially to take full advantage of the compact and efficient Slimline lamps, while at the same time offering all of the simplicity, ease of installation and flexibility of the Wiremold No. 2100 raceway. Note especially the compact cross section, ideal for special cove and valance effects. Remotely located ballasts are a great advantage in most installations of this kind, saving space and eliminating noise. Wiremold supplies convenient ballast boxes and connections are easily made. Write for further details or consult your Electrical Contractor.

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- UNIT OR CONTINUOUS STRIP INSTALLATION

12WM90

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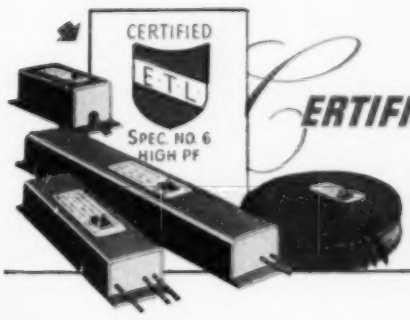

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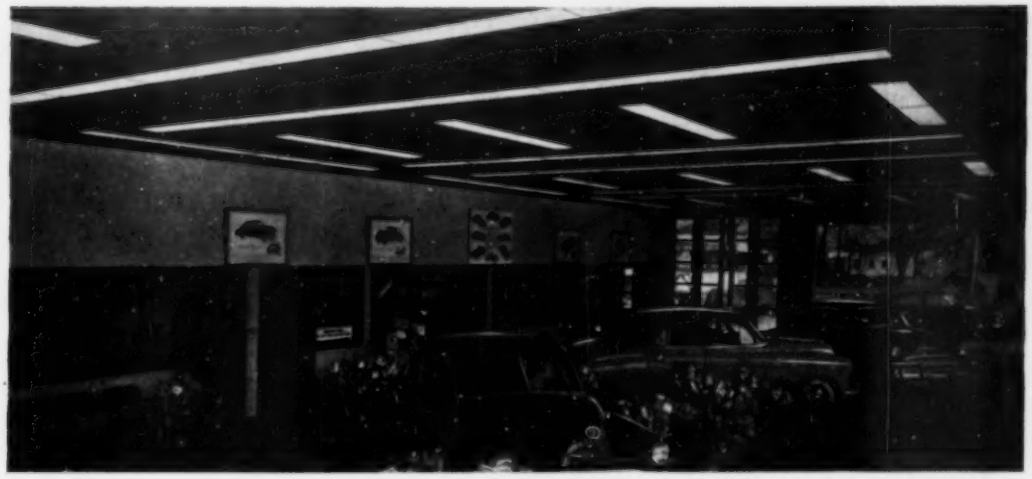

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